Comparison between mini mental state examination (MMSE) and Montreal cognitive assessment Indonesian version (MoCA-Ina) as an early detection of cognitive impairments in post-stroke patients

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Abstract. Mild cognitive impairment (MCI) is defined as cognitive impairment that may never develop into dementia. Cognitive impairment is one long-term complication of a stroke. The Mini Mental State Examination (MMSE), which is commonly used as a screening tool for cognitive impairment, has a low sensitivity to detect cognitive impairment, especially MCI. Alternatively, the Montreal Cognitive Assessment Indonesian version (MoCA-Ina) has been reported to have a higher sensitivity than the MMSE. The aim of this study was to compare the proportion of MCI identified between the MMSE and MoCA-Ina in stroke patients. This was a cross-sectional study of stroke outpatients who attended the Polyclinic Neuromuscular Division, Rehabilitation Department, and Polyclinic Stroke, Neurology Department Cipto Mangunkusumo General Hospital, Jakarta. The proportion of MCI identified using the MMSE was 31.03% compared to 72.41% when using the MoCA-Ina. This difference was statistically significant (Fisher’s exact test, \( p = 0.033 \)). The proportion of MCI in stroke patients was higher when using the MoCA-Ina compared to the MMSE. The MoCA-Ina should be used as an alternative in the early detection of MCI in stroke patients, especially those undergoing rehabilitation.

1. Introduction

Cognitive damage could affect treatment planning and rehabilitation program performance among patients. A cognitive function evaluation can provide recommendations about patients’ potentials and obstacles, which in the end will affect treatment duration, highlighting functional impairments in the patient, a matter of patient safety related to cognitive damage or the lack of a patient’s awareness of their impairments [1]. Mild cognitive impairment (MCI) is a term used to describe cognitive damage that does not meet the criteria of having dementia, and MCI does not necessarily develop into dementia [2]. To improve patients’ cognitive function and success in their rehabilitation programs, examining tools are needed with short screening times and with many cognitive aspects, such as orientation, language, and memory. No examination can definitively detect (gold standard) cognitive abnormalities. A full battery of cognitive tests is conducted in the Neurology Outpatient Clinic, RSCM, which could be the gold standard. Many measuring instruments can be used to screen cognitive function in adult rehabilitation patients, such as the Mini Mental State Examination (MMSE), Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), and
Neurobehavioral Cognitive Status Examination. Among these screening tools, the most commonly used at Cipto Mangunkusumo hospital is the MMSE. The MMSE consists of 11 questions that focus on many kinds of cognitive domains, including time and place orientation, short- and long-term memory, registrations, recalls, language, attention, visuo-construction, and the ability to understand and execute orders. This examination requires 5–10 minutes for completion. The MMSE was established by Folstein in 1975 [3]. Most researchers agree that a normal MMSE value is greater than or equal to 27, while a value of 22–26 indicates a suspicion of cognitive impairment and a value less than or equal to 21 indicates positive cognitive impairment. From the data in Indonesia, based on level of education, someone is considered to have cognitive impairment with an MMSE score of <27 for the high school level or higher, <25 for the junior high school level, <21 for the elementary school level, and <17 for the uneducated [4]. Based on a study conducted by Luis et al., among elderly patients in a community diagnosed with Alzheimer’s disease and MCI, it was confirmed that the MMSE (with a cut-off value of <24) is not sensitive enough to detect MCI. This study is also supported by Xu et al. and Trenkile et al., whose studies reached the same conclusions [5]. Therefore, additional sensitive screening tools are needed to detect MCI.

One of the best alternatives is the Montreal Cognitive Assessment (MoCA). Luis et al. stated that the MoCA with a cut-off value of <23 has a 96% sensitivity and 95% specificity in detecting cognitive impairment [6]. The MoCA is a cognitive screening tool that is not bounded by a patent and can be used for healthcare purposes freely. Meanwhile, the MMSE has been a patented product since 2010, profiting from fees charged to patients and increasing healthcare fees. However, this is not commonly known in Indonesia. The MoCA is a test that contains 30 questions, requires a 10-minute examination time, and includes more complex items than the MMSE to detect MCI. The items in the MoCA include short-term memory recalls and tests of visuo-spatial ability, executive function, attention, concentration, language, and time and place orientation. MoCA scores range between 0–30, with a higher score indicating better cognition and scores below 26 indicating cognitive impairment related to MCI and Alzheimer’s disease. To cope with the patient’s education effect, there is one additional point in patients with <12 years of education. To screen for MCI, the MoCA uses neuropsychological tasks that are more complex, and it consists of 12 items. Memory is tested by recalling short-term details (5 points), while visuo-spatial ability is tested using as task of drawing a clock (3 points) and a task of duplicating a three-dimensional cube (1 point). Executive function is tested using a follow-the-sequence test (1 point), a phonemic fluency task (1 point), and two items of verbal abstraction (2 points). Attention, concentration, and working memory are tested using a concentration task (1 point), a serial reduction task (3 points), and a memory task that requires the test taker to remember a row of numbers forward and backward (each of them 1 point). Language is tested by identifying three kinds of animals that are easy to recognize (lions, camels, rhinos; 3 points) and repeating two complex sentences (2 points), and time and place orientation is also tested (6 points) [7].

In a study conducted by Lee et al. in Korea, it was confirmed that the MoCA-K (using a cut-off score of 22/23) has a 89% sensitivity and 84% specificity for MCI screening. The MoCA-K’s internal consistency and test-retest reliability also show good scores. Therefore, the study concluded that the MoCA-K is a short, reliable, and suitable screening tool to test for MCI among elderly patients who seek treatment in polyclinics [8]. The MoCA has been tested for its validity and reliability for use in Indonesia using a transcultural study method and calibration between two testers. Good validation data are obtained as follows: 0.820 kappa total value, visuo-spatial/executive domain 0.817, identification 0.985, attention 0.969, language 0.990, abstraction 0.957, and orientation 1.00. From the result, it is concluded that the MoCA-Ina can be used to test cognitive function in Indonesia. The MoCA-Ina values have also been studied to be used in Indonesia, and these are 20 (six years of education), 24 (7–12 years of education), and 25.5 (>12 years of education) [4,9]. Cognitive impairment following a stroke patients is one of the most important but forgotten aspects in post-stroke rehabilitation. About 25% of patients will still experience dementia three months post-stroke. If single cognitive function impairment is also taken into account, 50–75% of stroke patients will experience it depending on their age [10]. The effect of a stroke on cognition is usually cumulative from the location, and the amount
of defects. The term strategic infarcts syndrome is used to describe a single infarct location. These strategic locations include the paramedian thalamus, inferomedial temporal cortex, dominant gyrus angularis, parietotemporal associated cortex, frontal lobes, basal ganglion, thalamus, and hippocampus or medial temporal lobes [11]. The aim of this study is to perform a comparison of the proportions of MCI identified in post-stroke patients between the MMSE and the MoCA-Ina. A secondary goal is to compare screening times between the MMSE and the MoCA-Ina to determine the relation between the characteristics of the subjects’ cognitive function and to identify the relation between the results of the MMSE and the MoCA-Ina.

2. Materials and Methods
This cross-sectional study focused on stroke patients who attended the Cipto Mangunkusumo General Hospital, Jakarta. Subjects were recruited consecutively. The inclusion criteria were patients aged 40–60 years who experienced a stroke three or more months prior, were conscious, had a minimum VIII Rancho Lo Amigos Level of Cognitive Functioning, speak Bahasa Indonesian, have noun corrected visual and hearing impairments, are literate, and are not suffering from aphasia. A statistical analysis was conducted to compare the proportions of MCI identified in patients using the MMSE and the MoCA-Ina, with a chi-square test if the requirements are fulfilled and Fisher’s exact test if otherwise. The result is statistically significant if \( p < 0.05 \) with a 95% confidence interval (CI). Descriptive data of numeric variables will be shown in the form of the mean value and standard deviation if there is a normal data distribution and as the median value and minimum-maximum if the data distribution is not normal. The categorical data will be displayed in the form of proportions, and data are processed using the SPSS 17 program for Windows.

3. Results and Discussion
3.1 Results
The average age of subjects is 53.03±5.34 years old. The proportions of cognitive impairment identified in patients using the MMSE and the MoCA-Ina are around 31.03% and 72.41%, respectively (Table 1). The MoCA-Ina can detect a greater proportion of cognitive impairments than the MMSE \( (p = 0.033) \), as shown in Table 2. The average screening time of the MoCA-Ina is significantly longer (more than twice) than the MMSE \( (6.00 [3.00–15.00] \text{ minutes vs. } 13.00 [8.00–25.00] \text{ minutes}) \) \( (p = 0.000) \), as determined by the Wilcoxon test. Based on a statistical analysis, there is no significant correlation between age and MMSE and MoCA-Ina values (Table 3).

| Variable | n | %  |
|----------|---|----|
| Gender   |   |    |
| Men      | 16| 55.2% |
| Women    | 13| 44.8% |
| Level of education | | |
| Elementary school | 5 | 17.2% |
| Junior high school | 3 | 10.3% |
| High school | 9 | 31.0% |
| Undergraduate/Bachelor | 12 | 41.4% |
| Occupation | | |
| Labor | 2 | 6.9% |
| Housewife | 6 | 20.7% |
| Cashier | 1 | 3.4% |
| Nurse | 1 | 3.4% |
| Government employee | 6 | 20.7% |
| Unemployed | 9 | 31.0% |
| Entrepreneur | 4 | 13.8% |

Table 1. Subject characteristics (n=29)
Table 1. Continued

| Variable                     | n  | %     |
|-----------------------------|----|-------|
| **Stroke onset**            |    |       |
| 3–7 months                  | 6  | 20.7% |
| 7–12 months                 | 8  | 27.6% |
| >12 months                  | 15 | 51.7% |
| **Weakness side**           |    |       |
| Right                       | 13 | 44.8% |
| Left                        | 13 | 44.8% |
| None                        | 3  | 10.3% |
| **Recurrent stroke history**|    |       |
| Found                       | 2  | 6.9%  |
| Not found                   | 27 | 93.1% |
| **Dexterity**               |    |       |
| Right handed                | 29 | 100%  |
| Left handed                 | 0  | 0%    |

Table 2. Mild cognitive impairment proportion comparison (cognitive damage) between MMSE and MoCA-Ina

| MMSE                     | MoCA-Ina                  |
|--------------------------|---------------------------|
| Cognitive impairment     | Normal                    |
| Cognitive impairment     | Normal                    |
| Normal                   | Total                     |
| 9                        | 0                         | 9                         |
| 12                       | 8                         | 20                        |
| 21                       | 8                         | 29                        |

*Fisher’s exact test p = 0.033*

*p < 0.005, MMSE abnormal cut-off point <27, MoCA-Ina<26

Table 3. Correlation of Age with MMSE and MoCA-Ina

| Variable                          | r   | p     |
|-----------------------------------|-----|-------|
| MMSE value – Age*                 | 0.048 | 0.805 |
| MoCA-Ina value – Age*             | 0.015 | 0.938 |

*Spearman test*  
*Pearson correlation*

Figure 1. MMSE and MoCA-Ina value description based on education level

Figure 1 shows a value comparison of the MMSE and the MoCA-Ina based on education level, and it shows that the value difference between education levels is more apparent in the MoCA-Ina than in the MMSE. This is shown by the MoCA-Ina difference, which has a more sloped curve. Based on the Spearman test, there is a moderate correlation between MMSE and MoCA-Ina values, and it is statistically significant (r = 0.678; p = 0.000). Based on a statistical analysis, the relation between the MMSE and the MoCA-Ina is determined to be statistically significant (p < 0.05).
3.2 Discussion
The average age of the subjects is 53.03±5.34 years old. The age of the subjects in this study was limited to 40–60 years old to reduce bias in terms of cognitive impairment caused by the degenerative process or aging and that is usually found in the geriatric population, as the definition of geriatric is 60 years old and above. Through this limitation, the form of cognitive impairment found is expected to be an effect of a stroke suffered by the patient, not the degenerative process. This is also according to a survey performed by the Asian Neurologic Association (ANA) in 28 hospitals in Indonesia, which states that most stroke sufferers (54.7%) are between 45 and 64 years old, while 11.8% are below 45 and 33% are above 65 years old [12]. In this study, 55.2% of subjects are men and 44.8% are women. This is comparable to a previous study conducted in RSUP. Dr. Kariadi, Semarang, where 68.9% of stroke sufferers were men and 31.1% were women [13]. Men have a higher stroke incidence than women until the age of 75, and from 75 on, stroke incidence is found to be higher in women. This is caused by the estradiol hormone, which has a vasodilatation effect on the blood vessel endothelium. During menopause, the hormone’s level will decrease and subsequently increase stroke risk [14]. In this study, the subjects’ education levels were determined to be high, with around 41.4% having achieved the undergraduate/bachelor degree level, followed by high school at 31.0%, elementary school at 17.2%, and junior high school at 10.3%. This is not in agreement with Cabral et al., who stated that stroke incidence has a negative correlation with the number of years of education undertaken by the patient [15]. This could be because this study includes stroke patients that are not hospitalized or in a control treatment as subjects, not acute stroke patients who are hospitalized. The patients’ obedience in attending control appointments is also affected by their level of education, and it appears that people with a higher level of education have a higher stroke incidence. Around 31% of subjects are not employed after suffering from a stroke, while the remainder still has their jobs, even though some of the work is different from before. This is in agreement with a study that stated 50% of stroke patients of reproductive age return to their occupations. The number of people who return to work is affected by muscle strength (normal vs. parese, OR 5.16), apraxia (found vs. not found, OR 1.43), and the kind of occupation (white collar vs. blue collar, OR 1.43) [16].

This study includes samples with stroke onset from three months and above, because the optimum cognitive function rehabilitation occurs in the first three months after stroke, though it is not accompanied by aphasia. This is more caused by a local deficit rather than a general deficit [17-18]. The MoCA-Ina can detect mild cognitive impairment better than the MMSE. In total, 21 people (72.41%) are detected using the MoCA-Ina and nine (31.03%) using the MMSE. The proportion difference is statistically significant using Fisher’s exact test. This is almost similar to Toglia et al., who compared the MoCA and the MMSE in their study of patients with light sub-acute stroke, where the proportions of cognitive impairment detected using the MoCA and the MMSE were 89% and 63%, respectively. The study also uses 27 as a cutoff point for the MMSE and 26 for the MoCA [19,20]. The same has also been stated by Cumming et al., who conducted a study on stroke patients three months after onset using the MoCA to detect any cognitive impairment. The study show that only 35% of the subjects received a normal MoCA value using 26 as the cutoff point, while the rest (62%) were detected as having cognitive impairment [21]. In this study, there are 12 subjects (60%) with a normal MMSE result, but when screened with the MoCA-Ina, some have abnormal results. This is in agreement with the study conducted by Pedlebury et al., which has the same result that 58% of patients had a normal MMSE value (> 27), but when screened with the MoCA-Ina, they had abnormal results (< 26). In the study, it is also stated that the patients are more dependent (based on the Rankin scale) than the patients with a normal MoCA value [22].

According to Pedlebury et al., the MMSE has a downside in that it has a high ceiling effect, while the MoCA can detect cognitive impairments that cannot be detected by the MMSE because the MoCA also examines the executive function component and attention, which are not examined in the MMSE. Besides, the recalling question items and the repetition in the MMSE are too easy for the patients [22]. Godefroy et al. in their study state that the MMSE has a low sensitivity to detect cognitive impairments caused by vascular damage. While the MoCA has a higher sensitivity, its specificity is
still low when compared to the battery of neuropsychology tests. If the MoCA is used as an early detection or screening tool, it has a high sensitivity [23]. In the study performed by Cumming et al., it is stated that the MoCA has a >80% sensitivity in detecting MCI when compared to the MMSE, which has a <20% sensitivity. The same has also been found in the stroke population. The prevalence of MCI in a MoCA examination can explain its high sensitivity, but this can also be caused by the normal/low-high cutoff point for some certain populations. In the study, the obtained result showed that the items that need attention and executive function, which are trail making, cube copy, and letter fluency. The word-recall examination result is also bad, as this describes memory impairment post-stroke, but this deficit is only detected in rather difficult tasks. The time and place orientation examination gives high points, and this shows that the MMSE is too focused on orientation (10 from 30 points) and this is not suitable for the stroke population [21].

There is a moderate correlation that is statistically significant between MMSE and MoCA-Ina values (r = 0.671; p = 0.000). This shows that the MoCA-Ina can describe cognitive function, as well as the MMSE, which is the most-used measuring tool recently. The total average value of the MoCA-Ina is significantly lower than that of the MMSE. The total values of both measuring tools are the same, which is 30. This is actually difficult to compare because the different cognitive items examined and the difficulty level in the MoCA-Ina are more difficult than the MMSE. Today, the MMSE is the most-used and easiest-to-use cognitive screening tool, even though there are several studies demonstrating that the MMSE has low sensitivity to detect cognitive impairment and sometimes even fails to detect it. The MoCA has been developed as a cognitive screening tool to detect mild-moderate cognitive impairment. Some of its benefits are it has a lower ceiling effect than the MMSE, a better internal reliability, and a stronger association to determine functional status. However, in this study, these things cannot be researched further because of the small number of samples. In the studies performed by Dong et al. and Godefroy, it was stated that the MoCA is superior in detecting cognitive impairment caused by a vascular abnormality after undergoing the acute stroke phase. The study applied a MoCA examination 14 days after stroke onset [23,24]. Nasreddine et al. suggest the use of the MMSE and MoCA-Ina in two different populations. The MMSE is better for patients with a lack of memory and daily functional status damage. Meanwhile, the MoCA-Ina is suggested for use in patients with a lack of memory but who do not have damage to their functional status; patients in this population usually have normal MMSE values [25].

Based on the time median analysis result between the MMSE and the MoCA-Ina, it is found that the MoCA-Ina requires a longer examination time of 13 minutes compared to the MMSE, which only needs six minutes. This may be due to the question items in the MoCA-Ina, as they are more complicated and greater in number than in the MMSE. The MoCA-Ina consists of visuospatial/executive function, identification, memory, attention, language, abstraction, delayed memory, and orientation components (18 separate questions). Meanwhile, the MMSE only consists of orientation, registration, attention and calculation, recall, and language components (11 separate questions). Besides, the MMSE has also been applied to patients either during their hospitalization period or during their control appointments, because the MMSE is a commonly used measuring tool. Meanwhile, the MoCA-Ina is a new screening tool and the patients have not answered the questions before. The time needed is also similar to Aggarwal et al., in whose study it was determined that the time needed to complete the MMSE is 7.4 minutes, while the time needed to complete the MoCA is 14.8 minutes [26]. The MoCA-Ina does require more time than the MMSE, but this is in agreement with the research results and also provides a more comprehensive description of the many cognitive aspects in patients. The aspects assessed in the MoCA-Ina can also be used as a model to determine the potentials in patients, where these potentials can be used to their maximum ability in the rehabilitation process to increase patients’ functional ability. In the end, it is expected that the patients can improve their independency and quality of life. This study shows no significant correlation between age and MMSE and MoCA-Ina values. This may be caused by the small number of samples. According to the meta-analysis performed by Verhaeghen et al., there is significant negative correlation between age and cognition in patients aged 18–50 years old [27].
There is correlation between level of education and MoCA-Ina values in this study. This correlation is related to brain plasticity, where during the education process neuron cells are activated and stimulated to continue growing, so that the earlier and the longer someone receives an education, the better for their cognitive function [4]. In the study performed by Falch and Massih on the correlation between intelligence improvement (IQ) and the duration of someone’s education, it was determined that one year of school will improve IQ by 2.9–3.5 points [28]. Cummings et al. in their study determined that a high education will delay dementia onset.4 In another study conducted by Kee et al., it was shown that women with a bachelor’s degree have a lower risk than people with an undergraduate degree in the case the basic cognitive function and a decrease in cognitive function in the same period [7]. From the result, it can be seen that the difference in the average values between the MMSE and the MoCA-Ina is statistically significant between the basic and high education levels. This is in agreement with the study mentioned above that states that the higher someone’s level of education, the better their cognitive function. This is also affected by other factors related to a high education level, such as good socio-economic level, varied social activities, better access to information, etc. The obstacles and disadvantages of this study include the difficulty to get samples that meet the inclusion criteria, particularly those between 40–60 years old. The samples are taken from the RSCM outpatient poly during rush house, as patients still of productive age would likely be at their place of work. Besides, there is a new policy in the hospital about cases that should be handled using primary and secondary care; RSCM is a tertiary healthcare, so many stroke cases are referred to regional public hospitals. Meanwhile, he cases handled at RSCM are more difficult and involve many complications; so many patients could not meet the sample criteria.

4. Conclusion
The proportion of MCI in post-stroke patients examined using the MoCA-Ina is greater than using the MMSE. Therefore, it is suggested that the MoCA-Ina be used as a screening cognitive test for post-stroke patients, especially those in rehabilitation programs. Further research is expected to offer more samples from more of a multi-center sampling place.

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