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The usefulness of the Loewenstein Occupational Therapy Cognition Assessment in evaluating cognitive function in patients with stroke

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Abstract. – OBJECTIVE: We wished to evaluate the usefulness of the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) in early detection of the Vascular Cognitive Impairment, No Dementia (VCIND) in patients with stroke. We also wanted to compare LOTCA with the Mini-Mental State Examination (MMSE).

PATIENTS AND METHODS: Thirty patients with stroke and cognitive impairment comprised the cognitive impairment group. Another 30 patients with stroke and no cognitive impairment served as the stroke control group, while 30 healthy individuals served as the normal control group.

RESULTS: The age, gender, and education level were comparable among three study groups. All subjects were assessed with both tests. Total LOTCA scores strongly and positively correlated with total MMSE scores in patients with cognitive impairment ($r = 0.934$, $p < 0.001$). The correlations were also present between every sub-items of LOTCA and those of MMSE ($p < 0.01$). In addition, total scores and sub-item scores in LOTCA were significantly lower in the cognitive impairment group compared with both stroke control and normal control groups ($p < 0.01$), especially, with regard to scores of thinking operations, orientation, and visuomotor organization. The sub-item scores in LOTCA, including thinking operations, visuomotor organization, attention, orientation, and spatial perception were significantly lower in the stroke control group compared with normal control group ($p < 0.01$), especially in thinking operations and visuomotor organization. There is a good agreement between LOTCA and MMSE.

CONCLUSIONS: Compared with MMSE, LOTCA can detect VCIND earlier and more comprehensively, and can, thus, be used clinically for VCIND detection.

Key Words:

Stroke, Loewenstein occupational therapy cognitive assessment, Vascular cognitive function impairment, Mini-mental state examination, Comparison.

Introduction

The Loewenstein occupational therapy cognition assessment (LOTCA) is a relatively systematic assessment method for current occupational therapies. This method demonstrates favorable confidence, efficacy, and sensitivity in evaluation of diseases of central nervous system (CNS)[1,2]. However, the usefulness of LOTCA in diagnosing the condition called Vascular Cognitive Impairment, No Dementia (VCIND) has not been established yet. In this study, patients with stroke were evaluated by both Mini-Mental State Examination (MMSE) and LOTCA, and correlation between these two tests was examined.

Patients and Methods

Patients

In total, 60 right-handed patients with stroke, aged from 40 to 76 years, who were admitted to the Department of Rehabilitation of our Hospital from September 2009 to October 2010, were enrolled in our study. The inclusion criteria were as follows: (1) documented history of stroke, with the diagnosis made according to the established diagnosis criteria[3] and confirmed by head CT or MRI exams, (2) education level: primary school or higher, (3) recent (i.e., within three last months) disease onset, d) full consciousness, stable disease, and capability to comply with intended tests, and (4) informed consent signed by the patient and/or guardian. The exclusion criteria were: (1) pre-existing cognition defects or suspicious cognition disorders, such as psychiatric history, mood disorders, alcohol or drug abuse, (2) severe language dysfunction and/or bi-

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lateral limb motor dysfunction, and incapability to participate in clinical psychology tests, c) severe visual and/or auditory disorders, and d) comorbidities with rapid progression or serious complications.

Our cognitive impairment group included 30 patients with stroke. Cognitive impairment was established according to the diagnostic criteria of MMSE[4]. The patients had primary education level of < 20 points and secondary education level or higher of < 24 points on the subscales of MMSE. The study individuals in this group comprised 23 male and 7 female patients, aged from 40 to 76 years (mean ± SD age of 60.57 ± 12.00 years). Seven patients in this group had primary level of education, 13 patients – secondary education, and 10 patients reported middle-school or higher education. There were 15 patients with cerebral infarction and 16 with cerebral hemorrhages. The average duration of the disease was 61.03 ± 28.46 days.

We also had a stroke control group comprising patients with stroke but without marked cognitive impairment. These patients had primary education level of ≥ 20 points and secondary education level or higher of ≥ 24 points. This group included 23 male and 7 female patients, aged from 40 to 76 years old (59.63 ± 12.04 years). Seven patients had primary education only, 12 patients were educated at secondary level, and 11 patients received senior middle school education or higher. There were 16 patients with cerebral infarction and 14 with cerebral hemorrhage. The average duration of the disease was 65.53 ± 25.25 days.

In addition to the above groups, we also recruited a healthy control group comprised of 30 healthy volunteers whose age, gender, and education level matched those of patients in the above groups. Specifically, there were 23 male and 7 female individuals aged 40 to 76 years old (59.47 ± 12.52 years). With regard to education level, there were 7 individuals with primary level of education, 11 with secondary education, and 12 with senior middle school or higher education level. To be included in the healthy control group, the individuals had to: (1) have no congenital or acquired histories of CNS disease (including traumatic brain injury, cerebrovascular accident, etc.), (2) exhibit no abnormal CNS findings, (3) have no history of drug or alcohol abuse, as well as no psychiatric history or family history of mental illness, d) be willing to comply with the study protocol and sign informed consent, and e) show 29-30 MMSE points.

The groups were not statistically different in their gender distribution, age, education level ($p > 0.05$ for all comparisons; Table I).

In each study individual, cognitive function was assessed by both LOTCA and MMSE, with LOTCA following MMSE.

LOTCA

LOTCA includes 26 sub-items in six areas: orientation (sub-items 1 and 2), visual perception (sub-items 3-6), spatial perception (sub-items 7-9), praxis (sub-items 10-12), visuomotor organization (sub-items 13-19), thinking operations (sub-items 20-26), memory (sub-items 20-26), and attention and absorption (1 sub-item). The

Table I. Patient demographic and clinical data.

Parameter	Cognitive impairment group	Stroke control group	Normal control group	$F/t/\chi^2$	p
Age, years	60.57 ± 12	59.63 ± 12.04	59.47 ± 12.52	F = 0.071	0.932
Gender (male/female)	23/7	23/7	23 /7	$\chi^2 = 0.0$	1.0
Educational background: primary school/middle school/high school or technical secondary school/college	7/13/7/3	7/12/8/3	7/11/8/4	$\chi^2 = 0.449$	0.998
Type of stroke: cerebral infarction/ cerebral hemorrhage	15/15	16/14		$\chi^2 = 0.067$	0.796
Disease course at enrollment	61.03 ± 28.46	65.53 ± 25.25		$t = -0.648$	0.52

Footnote: The data are presented as mean ± SD or absolute numbers.

scoring was made on an ordinal scale of 1-8 points for sub-items 1 and 2, 1-5 points for sub-items 1-5, and 1-4 points for other sub-items, with 115 points for the overall score and 4 points for an attention sub-item.

MMSE

MMSE includes 30 sub-items on a scoring scale of 1-30 points. For the purpose of analysis, the test's content was divided into the following six fields: orientation (10 sub-items), memory (6 sub-items), attention and calculation (5 sub-items), language (4 sub-items), execution (4 sub-items), and visual-spatial ability (1 sub-item).

Statistical Analysis

The results were analyzed with SPSS16.0 software package (SPSS Inc., Chicago, IL, USA). Qualitative data were analyzed by the chi square test. Quantitative data were represented as mean ± SD and analyzed by normal distribution test. For two case groups, the scores of LOTCA and MMSE tests demonstrated normal distributions; therefore, correlation between the tests was analyzed by Pearson correlation test. To analyze correlations between total scores, sub-items, or inter-sub-items, the Spearman's rank correlation was utilized. To compare average values among three groups, the Kruskal-Wallis Rank-Sum test was utilized. The pair-wise comparisons between LOCTA scoring sub-items were analyzed using SAS9.1.3 software package, by rank-sum test. The p value of < 0.05 was considered statistically significant.

Results

Comparison Between LOTCA and MMSE

Normal distributions of total scores of LOTCA and MMSE tests were demonstrated in 60 patients with stroke. A strong and significant correlation between the total scores of both tests was shown by Pearson correlation test ($r = 0.934$, $p < 0.001$), with a trend of apparent positive correlation observed on a correlation scatter plot (Figure 1). Further, as shown by Spearman correlation test, there were moderate to high correlations between the total scores of LOTCA and the scores of MMSE sub-items, and between any LOTCA sub-item scores and the total scores of MMSE (Table II). In addition, statistically significant correlations were demonstrated between all LOTCA sub-items and all MMSE sub-items ($p < 0.05$). Age and education level had similar effects on both tests and did not correlate with the total scores of both tests (Table II).

The correlations between the total scores of both tests in three groups ranged from moderate to strong (Table III). The lowest correlation coefficients were observed in the stroke control group (Table III). Further, correlations between LOTCA sub-items of visuomotor organization and attention/absorption, and total MMSE scores were relatively low in the cognitive impairment group ($r = 0.513$, $p = 0.004$, and $r = 0.364$, $p = 0.048$; Table III). In addition, in the stroke control group, the correlation between visuomotor organization score and the total MMSE score was also relatively low ($r = 0.444$, $p = 0.014$; Table III).

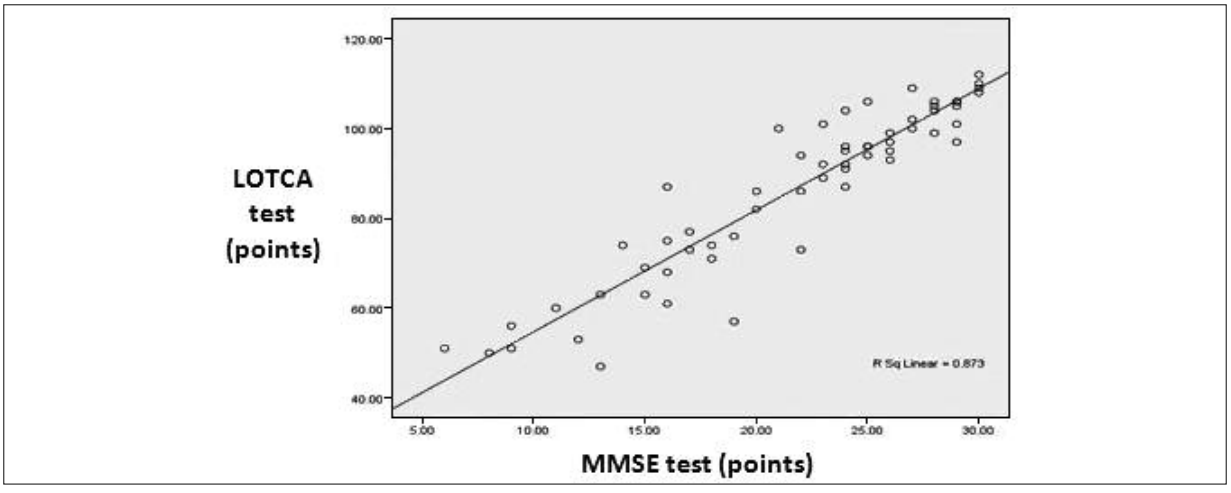

Figure 1. Correlations between total scores of LOTCA and MMSE in patients with stroke (n = 60). Total scores of two tests strongly correlated: Pearson correlation test $r = 0.934$, $p < 0.001$.

Table II. Correlations between LOTCA and MMSE in two stroke groups (n = 60).

			MMSE						
LOTCA	Age	Education background	Orientation	Memory	Attention and calculation	Language	Execution	Visual/spatial ability	Total score
Age	1	-0.205 (0.117)	-0.143 (0.277)	-0.085 (0.516)	-0.132 (0.313)	0.043 (0.742)	-0.155 (0.236)	-0.102 (0.438)	-0.100 (0.448)
Education background	-0.205 (0.117)	1	0.157 (0.232)	0.086 (0.513)	0.203 (0.120)	0.273* (0.035)	0.249 (0.055)	0.050 (0.707)	0.189 (0.148)
Orientation	-0.095 (0.469)	0.154 (0.240)	0.927** (< 0.001)	0.733** (< 0.001)	0.749** (< 0.001)	0.617** (< 0.001)	0.473** (< 0.001)	0.462** (< 0.001)	0.910** (< 0.001)
Visual perception	-0.032 (0.806)	0.035 (0.788)	0.746** (< 0.001)	0.679** (< 0.001)	0.635** (< 0.001)	0.525** (< 0.001)	0.494** (< 0.001)	0.522** (< 0.001)	0.774** (< 0.001)
Spatial perception	-0.335** (0.009)	0.422** (0.001)	0.595** (< 0.001)	0.437** (< 0.001)	0.461** (< 0.001)	0.434** (0.001)	0.579** (< 0.001)	0.348** (0.006)	0.601** (< 0.001)
Praxis	-0.176 (0.178)	0.169 (0.196)	0.603** (< 0.001)	0.581** (< 0.001)	0.679** (< 0.001)	0.413** (0.001)	0.503** (< 0.001)	0.402** (0.001)	0.686** (< 0.001)
Visuo-motor organization	-0.269* (0.037)	0.140 (0.287)	0.696** (< 0.001)	0.627** (< 0.001)	0.654** (< 0.001)	0.503** (< 0.001)	0.524** (< 0.001)	0.643** (< 0.001)	0.759** (< 0.001)
Thinking operations	-0.245 (0.059)	0.222 (0.088)	0.809** (< 0.001)	0.752** (< 0.001)	0.732** (< 0.001)	0.595** (< 0.001)	0.611** (< 0.001)	0.616** (< 0.001)	0.872** (< 0.001)
Attention	-0.103 (0.432)	0.098 (0.458)	0.618** (< 0.001)	0.589** (< 0.001)	0.529** (< 0.001)	0.350** (0.006)	0.405** (0.001)	0.448** (< 0.001)	0.651** (< 0.001)
Total score	-0.223 (0.086)	0.239 (0.066)	0.884** (< 0.001)	0.761** (< 0.001)	0.759** (< 0.001)	0.631** (< 0.001)	0.622** (< 0.001)	0.638** (< 0.001)	0.934** (< 0.001)

Footnote: Data are correlation coefficients. Numerical values in parentheses are p values. *$p < 0.05$, **$p < 0.01$ (two-tailed test).

Table III. Correlation between LOTCA sub-items and total MMSE score.

MMSE total score	LOTCA							
	Orientation	Visual perception	Spatial perception	Praxis	Visuo-motor organization	Thinking	Attention	Total score
Cognitive impairment group	0.738** (< 0.001)	0.689** (< 0.001)	0.526** (0.003)	0.699** (< 0.001)	0.513** (0.004)	0.715** (< 0.001)	0.364* (0.048)	0.839** (< 0.001)
Stroke control group	0.835** (< 0.001)	0.469** (0.009)	0.514** (0.004)	0.599** (< 0.001)	0.444* (0.014)	0.511** (0.004)	0.625** (< 0.001)	0.750** (< 0.001)
Healthy control group	0.499** (0.005)	0.757** (< 0.001)	0.488** (0.006)	0.509** (0.004)	0.639** (< 0.001)	0.745** (< 0.001)		0.789** (< 0.001)

Footnote: Data are correlation coefficients. Numerical values in parentheses are p values. *$p < 0.05$, **$p < 0.01$ (two-tailed test).

For other sub-items, there were statistically significant correlations between both tests ($p < 0.01$; Table III).

Comparisons Between LOTCA Sub-Items and Total MMSE Score

The total LOTCA score and any sub-item scores were significantly lower in the cognitive impairment group compared with the both other groups ($p < 0.01$; Table IV), especially for the sub-items of thinking operations, orientation, visuomotor organization, and attention and spatial perception, which respectfully accounted for 45.1%, 57.3%, 58.6%, 70.6% and 72.8% of the total score. As for the stroke control and healthy control groups, with the exception of visual perception and praxis, which were not-significant, the sub-item scores of orientation, spatial perception, visuomotor organization, additional attention and absorption were all significantly lower in the stroke control group ($p < 0.01$; Table IV).

The total MMSE score was markedly lower in the cognitive impairment group compared with both stroke control group and healthy control groups ($p < 0.01$; Table IV). Further, the total MMSE score was also significantly lower in the stroke control group, compared with healthy control group ($p < 0.01$; Table IV).

Discussion

Cognitive impairment is often observed following stroke and has a great negative impact on the quality of life of the patients[5]. Specifically, the prevalence of post-stroke cognitive impairment can be as high as 64%, and up to one third of the patients experience apparent dementia[6]. The cognitive impairment induced by, or related to, vascular factors is called Vascular Cognitive Impairment (VCI). VCI is classified based on clinical characteristics and disease severity into vascular cognitive impairment, no dementia (VCIND), vascular dementia (VaD), and mixed dementia[7]. Patients usually experience VCIND in very early stages of their condition, with very mild and occult symptoms. This is the most optimal stage to prevent VaD[7,8]. However, there are no definite classification system and no recognized neuropsychological tests for VCIND[9,10]. Therefore, in the present study, we tested the usefulness of LOTCA in the diagnosis of VCIND. The LOTCA was compared with MMSE, since the latter is the most popular and widely applied

Table IV. Correlation between total MMSE scores and LOTCA sub-item scores.

Group	MMSE total score (30 points)	Orientation (16 points)	Visual perception (16 points)	Spatial perception	Praxis (12 points)	Visuo-motor organization	Thinking operation (31 points)	Attention (4 points)	Total LOTCA score (115 points)
Cognitive impairment group	16.43 ± 4.78$^{**,\#}$	9.17 ± 3.28$^{**,\#}$	12.90 ± 2.51$^{**,\#}$	8.73 ± 2.72$^{**,\#}$	10.8 ± 1.35$^{**,\#}$	16.40 ± 4.65$^{**,\#}$	13.97 ± 5.71$^{**,\#}$	2.83 ± 0.59$^{**,\#}$	71.97 ± 15.38$^{**,\#}$
Percentage when compared to the total score (%)	54.8	57.3	80.6	72.8	90	58.6	45.1	70.6	62.6
Stroke control group	26.87 ± 2.15$^{\#}$	14.33 ± 1.45$^{\#}$	15.37 ± 0.58	10.87 ± 1.70$^{\#}$	11.73 ± 0.45	23.27 ± 2.66$^{\#}$	25.1 ± 2.28$^{\#}$	3.50 ± 0.57$^{\#}$	100.67 ± 6.45$^{\#}$
Percentage when compared to the total score (%)	89.6	89.6	96.1	90.6	97.8	83.1	81.0	87.5	87.5
Healthy control group	29.70 ± 0.47	15.77 ± 0.43	15.73 ± 0.45	11.83± 0.38	11.90 ± 0.31	26.30 ± 1.15	28.37 ± 1.41	4.00 ± 0	109.9 ± 3.27
Percentage when	99	98.6	98.3	98.6	99.2	93.9	91.5	100	95.6
H	73.169	64.816	42.777	31.968	27.602	57.288	68.902	48.780	68.142
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Footnote: Data are correlation coefficients. Numerical values in parentheses are *p* values. $^{*}p < 0.05$, $^{**}p < 0.01$ (two-tailed test).

tool for cognitive function screening. The MMSE is a simple, time non-consuming, and easy test, with proven validity and confidence[11]. This test mainly reflects orientation capability, memory, and language skills, and has no precise subscales. The visuospatial capability is examined only in a subscale, and the tests of visuomotor organization and thinking operations are not included. Moreover, the results may be influenced by education level, leading to false positive or negative results. Therefore, MMSE is only recommended to diagnose severe cognitive impairment or VaD. However, the utility of this test in the diagnosis of VCI is limited due to low sensitivity and specificity. Therefore, the early stage VCI may be overlooked by this test[12]. Thus, MMSE is not very useful to assess cognitive impairment and response of treatment[1,13].

The LOTCA is based on the Luria neuropsychological and Piaget's development model[14]. The test introduces multiple tasks into cognitive assessment, and features comprehensive evaluations and simple procedures. The cognitive status can be examined in the fields of orientation, agnosia, apraxia, incapability to write, distinguishing difficulty in graph backgrounds, naming disorders, unilateral neglect, visual concept formation, visuospatial capability to organize and reasoning, thinking, attention, executive power and other aspects. Patients with speech impairment can utilize an atlas to exclude possible interference of language factors on the test. The LOTCA can be used not only in the assessment of cognitive function, but also when deciding the treatment following the initial assessment. It was shown[15] that LOTCA can be useful to predict the extent of overall functional improvement following stroke. The predictive power of this test appears to be slightly higher compared with MMSE and functional independence measure[15].

In our study, significant positive correlations were demonstrated between all items of both LOTCA and MMSE, suggesting full eligibility of LOTCA in the cognitive function assessment of cerebrovascular disease. Some patients with stroke also demonstrated focal cognitive impairment in the performance of visuomotor organization and thinking operations, and this was not detected using MMSE. The subscale of visuomotor organization could be utilized to examine functional impairments associated with visuospatial organization, such as structural apraxia, unilateral neglect and spatial organization, with domination of the right hemisphere. By contrast, MMSE is more

sensitive to the functions of the left hemisphere, such as language skills. Therefore, total MMSE scores and scores of visuomotor organization are low in patients with impairment of the right hemisphere. Further, in patients with partial aphasia, low MMSE scores may be affected by diminished language skills, while the score of visuomotor organization remains acceptable. Therefore, we conclude that MMSE may not fully reflect VCI. Especially in assessment of VCIND, diminished consistency between LOTCA and MMSE was observed. In our study, we enroll individuals with primary or higher education levels to assess the interference of education level. The age and education levels were demonstrated to have similar effects on both LOTCA and MMSE and to be independent of the total scores of these scales, which may be not obvious due to stroke.

In our study, patients with stroke, with or without cognitive impairment, were selected according to the criteria of the MMSE test. VaD and VCIND were considered for some of these patients. As shown by us above, the score of each domain in the group of cognitive impairment was significanlty lower than in the stroke control group (i.e., patients with stroke but without cognitive impairment) and healthy control group, especially in the domains of thinking operation, orientation and visual-motor organization. The scores of thinking operation, visuomotor organization, attention and concentration, orientation and spatial perception were significantly higher in the stroke control group compared with healthy control group, especially in the thinking operation and visuomotor organization. This indicated comprehensive nature of cognitive impairment induced by stroke, and involvement of multiple cognitive domains. Partial cognitive impairment may be present in patients without dementia. Most prominent impairments were observed in the sub-scales of thinking operation and visuomotor organization in both stroke groups, which was agreeable with progressive aggravation. Since the subscales of thinking operation and visuomotor organization are composed of category test, stuff classification, picture sorting, geometric reasoning, drawing a clock, imitation and construction, all of these tests to some extent reflect the executive function[16]. This suggested that executive impairment was the most prominent presentation in patients with VaD and VCIND, with a trend to progressive aggravation. Therefore, VaD was identified to be the clinical presentation of cognitive impairment in its advanced stage, with executive dysfunction as the most prominent presentation in its early stage. These results were consistent with neuropsychological characteristics of VCI described in the literature[17,18]. The multi-aspect cognitive impairments of attention, orientation, and spatial perception were observed in the stroke control group, with response and selection efficiency being slowed down due to the attention defect. Moreover, mild VCI is characterized by prominent efficiency impairments of executive function and information processing capability[19]. We used LOTCA to assess patients with stroke and no apparent cognitive impairment, who were consistent with characteristics of cognitive impairment. LOTCA is a powerful tool to detect features of cognitive impairment in VaD and VCIND, and can be utilized to detect mild cognitive impairment in the early stages. The sensitivity of this method is higher compared with that of MMSE. Therefore, LOTCA is a suitable alternative technique to detect VCIND.

As suggested in the studies of multiple sclerosis[20], each cognitive domain should be examined thoroughly to highlight a specific domain to comprehensively and objectively evaluate cognitive changes in VCI. The coverage of multiple cognitive domains by LOTCA is compliant with recommendations in[20]. The test items can target specific cognitive domains, and assessment of executive function is also included.

Conclusions

We demonstrate that LOTCA is capable of detecting cognitive impairment earlier and more comprehensively than MMSE. Patients with mild VCI were able to complete LOTCA within approximately 30 minutes. This method can be used to assess cognitive function of patients with VCIND for early detection of dementia in the clinical practice.

Conflict of Interest

The Authors declare that there are no conflicts of interest.

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