Chinese Journal of Traumatology 19 (2016) 271–274

Contents lists available at ScienceDirect

Chinese Journal of Traumatology

journal homepage: http://www.elsevier.com/locate/CJTEE

Original article

Differences in cognitive profiles between traumatic brain injury and stroke: A comparison of the Montreal Cognitive Assessment and Mini-Mental State Examination

Hao Zhang [a], Xiao-Nian Zhang [a], Hui-Li Zhang [b], Liang Huang [c], Qian-Qian Chi [a], Xin Zhang [a], Xiao-Ping Yun [b,*]

[a] Neurorehabilitation Department, Beijing Bo'ai Hospital, China Rehabilitation Research Center, School of Rehabilitation, Capital Medical University, Beijing 100068, China
[b] Rehabilitation Evaluation Department, Beijing Bo'ai Hospital, China Rehabilitation Research Center, School of Rehabilitation, Capital Medical University, Beijing 100068, China
[c] Rehabilitation Department, Huabei Oil Field Huayuan Hospital, Hejian 062450, Hebei, China

ARTICLE INFO

Article history:
Received 6 September 2014
Received in revised form
1 March 2015
Accepted 5 March 2015
Available online 19 July 2016

Keywords:
Montreal Cognitive Assessment
Mini-Mental State Examination
Cognitive impairment
Cognitive assessment
Brain injuries
Stroke

ABSTRACT

Purpose: To investigate the profiles of cognitive impairment through Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE) in patients with chronic traumatic brain injury (TBI) or stroke and to evaluate the sensitivity of the two scales in patients with TBI.

Methods: In this cohort study, a total of 230 patients were evaluated, including TBI group ($n = 103$) and stroke group ($n = 127$). The cognitive functions of two groups were evaluated by designated specialists using MoCA (Beijing version) and MMSE (Chinese version).

Results: Compared with the patients with stroke, the patients with TBI received significantly lower score in orientation subtest and recall subtest in both tests. MoCA abnormal rates in the TBI group and stroke group were 94.17% and 86.61% respectively, while MMSE abnormal rates were 69.90% and 57.48%, respectively. In the TBI group, 87.10% patients with normal MMSE score had abnormal MoCA score and in the stroke group, about 70.37% patients with normal MMSE score had abnormal MoCA score. The diagnostic consistency of two scales in the TBI group and the stroke group were 72% and 69%, respectively.

Conclusion: In our rehabilitation center, patients with TBI may have more extensive and severe cognitive impairments than patients with stroke, prominently in orientation and recall domain. In screening post-TBI cognitive impairment, MoCA tends to be more sensitive than MMSE.

Introduction

The high incidence of traumatic brain injury (TBI) in China is a result of rapid development in transportation and construction industry over the past decades. The epidemiology study showed that 60–70 people in every 100,000 in China suffered from TBI. One million additional TBI victims are estimated every year nationwide,[1,2] and tremendous economic and social resources are consumed, so the disease was regarded as "the silent epidemics" in last century. Cognitive impairment perhaps one of the most important factors influencing the rehabilitation outcome, is commonly observed in TBI survivors.[3] Effective cognitive rehabilitation is vital for better recovery and depends on targeted cognitive treatment which demands good evaluation. However, TBI rehabilitation in China now is at an early development stage and there is no specific rehabilitation system for the post-TBI cognitive impairment. Most patients with TBI still receive the same cognitive evaluation and rehabilitation as patients with stroke. Clinically, cognitive impairment caused by TBI and stroke is different in mechanisms, clinical manifestations, risk factors and outcomes.[4] Compared with patients with stroke, patients with TBI are younger and have a longer recovery that indicates a better rehabilitation outcome.[5] Therefore, it is necessary and urgent to establish the evaluation and rehabilitation system exclusive to post-TBI cognitive impairment. Up to date, there have been a few large clinical researches focusing on TBI cognitive impairment evaluation.

* Corresponding author.
E-mail address: crrck3@sina.com (X.-P. Yun).
Peer review under responsibility of Daping Hospital and the Research Institute of Surgery of the Third Military Medical University.

http://dx.doi.org/10.1016/j.cjtee.2015.03.007

The Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) are the two mostly adapted methods for cognitive impairment screening,[6,7] both of which have a Chinese version and their reliability and validity have been tested in previous studies.[8,9] Despite the common advantages such as simple application, exclusive coverage of cognitive domains and broad clinical application, two scales differ largely in their contents: MMSE emphasizes evaluation of speech and orientation while MoCA covers more cognitive domains, focusing on executive and visuoconstructive functions.[7,10–12] In comparison to MMSE, MoCA is better in the screening of mild cognitive impairments. It was reported that MoCA was better in sensitivity than MMSE when applied to the screening of mild cognitive impairments in diseases such as Alzheimer,[13] stroke[14–16] and Parkinson.[17,18] Although two scales have been introduced in cognitive evaluation of patients with TBI, the differences in their sensitivity and specificity are not clear. Which evaluation tool better fits stroke cognitive impairment for patients with TBI warrants further investigation. To address the above questions, we utilize both MMSE and MoCA to evaluate the cognitive impairment of both patients with TBI and with stroke. The differentiating cognitive profiles of TBI and stroke were explored to observe the sensitivities and advantages of MMSE and MoCA applied in TBI group. Our study may provide help in selecting a suitable tool for evaluating post-TBI cognitive impairment.

Materials and method

Patient selection

All procedures were in accordance with China Rehabilitation Research Center welfare guidelines and the study was approved by the Institutional Ethics Committee of China Rehabilitation Research Center. The participants gave their verbal informed consent, because they were only given MMSE and MoCA tests without any interventions. The participant consents were recorded by video, and the consent procedure was approved by the ethics committee. Patients admitted to our center for stroke (ischemia or hemorrhage) or TBI from January to December in 2012 were included. The stroke was diagnosed by the criteria of American Heart Association and TBI by the criteria of the American Congress of Rehabilitation Medicine. All patients suffered from first-ever stroke or TBI for 1–12 months.

Exclusive criteria included illiteracy, alcoholic or drug abuse, previous history of Alzheimer disease, Parkinson disease, degenerative diseases of nervous system or incapability of completing cognitive test for any conditions, such as conscious disorder, severe neuropsychological disorder, severe dysphasia, motor dysfunction of dominant hand and handicap of hearing or vision.

Data addressing

The baseline data of all participants such as sex, age of onset, educational level, medical history, region of lesion, etc were recorded in detail. Magnetic resonance imaging was performed for all patients.

Evaluation method

All patients were evaluated in awake and peace state by designated experts using MoCA (Beijing version) and MMSE (simplified Chinese version). Patients were randomized into two groups by selecting a number. Patients with odd number received tests in sequence of MMSE-MoCA, which was opposite for patients with even number. There was a 24 h interval between the two tests. A cutoff score of ≥27 on the MMSE was chosen to indicate normal cognitive function,[10,19] and a cutoff score of <26 on the MoCA was taken to indicate cognitive impairment (an additional point being added to the total score for patients with less than 12 years of education), according to the recommendation from published references.[7,15,16]

Statistical analyses

Comparisons between MMSE and MoCA subtest scores across memory in TBI and stroke groups were performed using ANOVA adjusted for age and education and pairwise comparisons with Student's t test for continuous variables and X^2 for categorical variables. Enumeration data were presented as absolute value and percentage, while measurement data were expressed as the mean ± SD. X^2 test and t test were performed to evaluate the significance of the difference between two groups. SPSS 16.0 software (SPSS, Chicago, IL, USA) was used. A value of $p < 0.05$ was considered statistically different and $p < 0.01$ was considered statistically significantly different.

Results

Baseline data of patients

A total of 230 patients (103 with TBI, 127 with stroke) were included in our study. Their baseline data were showed in Table 1. There was no difference in education level between two groups ($p > 0.05$). There was statistically difference in sex distribution ($p < 0.05$) and significantly different in onset age ($p < 0.01$) between two groups. More males were included in TBI group (TBI vs. stroke: 84.47% vs. 73.23%). Onset age was younger in TBI group (TBI vs. stroke: 35.9 ± 13.08 years vs. 53.87 ± 13.18 years). More bilateral frontal, temporal and diffusive lesions were observed in patients with TBI. Unilateral lesions, most in basal ganglia region, were observed more frequently in patients with stroke. There was no difference between two groups in parietal lesions.

Comparisons of total scores and subtests scores in both groups

Table 2 indicates that, in both tests, total score of TBI group was significantly lower than that of stroke group, while there was significant difference in subtests score of orientation and recall between the two groups.

Distribution of MMSE and MoCA scores in both groups

Shown in Table 3, the sensitivity of MMSE to TBI was 69.90% while MoCA was 94.17%. The consistency test of two scales showed:

Table 1
The comparison of baseline data between two groups.

	TBI ($n = 103$)	Stroke ($n = 127$)	p value
Male (n, %)	87 (84.47%)	93 (73.23%)	0.040
Onset age (means ± SD) years	35.9 ± 13.08	53.87 ± 13.18	<0.01
Educational level P50 (P25, P75)	9 (9,16)	9 (9,16)	0.696
Years			
Education ≤ 12 years (%)	66 (64.08%)	80 (62.99%)	0.865
Inflicted side (n, %)			
Left	21 (20.39%)	44 (34.65%)	<0.01
Right	25 (24.27%)	73 (57.48%)	<0.01
Bilateral	57 (55.34%)	10 (7.87%)	<0.01
Affected area			
Frontal lobe	31 (30.10%)	18 (14.17%)	<0.01
Temporal lobe	36 (34.95%)	21 (16.54%)	<0.01
Parietal lobe	20 (19.42%)	19 (14.96%)	0.371
Basal ganglion	17 (16.50%)	94 (74.02%)	<0.01
Diffusive	39 (37.86%)	3 (2.36%)	<0.01
Two or more areas	68 (66.02%)	43 (33.86%)	0.017

Table 2
Comparisons of total scores and subtests scores between MMSE and MoCA.

	TBI ($n = 103$)	Stroke ($n = 127$)	t value	p value
MMSE				
Total/30	18.63 ± 8.93	22.16 ± 7.75	3.157	0.001
Orientation/10	5.76 ± 3.52	7.63 ± 3.18	4.234	<0.001
Registration/3	2.50 ± 1.01	2.69 ± 0.78	0.632	0.055
Calculation/5	2.67 ± 1.96	2.85 ± 1.92	0.704	0.509
Recall/3	1.50 ± 1.21	1.90 ± 1.13	2.606	0.012
Naming/2	1.77 ± 0.63	1.84 ± 0.51	0.983	0.413
Repetition/1	0.72 ± 0.45	0.80 ± 0.40	1.489	0.133
Comprehension/3	2.17 ± 1.11	2.35 ± 0.98	1.304	0.213
Reading/1	0.77 ± 0.42	0.85 ± 0.36	1.587	0.107
Writing/1	0.55 ± 0.50	0.62 ± 0.49	1.051	0.293
Drawing/1	0.52 ± 0.50	0.61 ± 0.49	1.367	0.171
MoCA				
Total/30	14.84 ± 6.70	17.43 ± 7.23	3.157	0.007
Visuoexecutive/5	2.18 ± 1.53	2.54 ± 1.63	4.234	0.106
Naming/3	1.92 ± 1.17	2.21 ± 0.97	0.632	0.092
Digit span/2	1.49 ± 0.68	1.50 ± 0.65	0.704	0.920
Attention/1	0.50 ± 0.50	0.57 ± 0.50	2.606	0.291
Calculation/3	2.04 ± 1.18	2.16 ± 1.05	0.983	0.621
Repetition/2	0.71 ± 0.72	0.85 ± 0.78	1.489	0.178
Verbal fluency/1	0.43 ± 0.50	0.54 ± 0.50	1.304	0.080
Abstraction/2	0.58 ± 0.69	0.73 ± 0.81	1.587	0.221
Recall/5	0.81 ± 1.36	1.35 ± 1.73	1.051	0.020
Orientation/6	3.83 ± 1.91	4.51 ± 1.73	1.367	0.003

Table 3
Comparisons between MMSE and traumatic brain injury (TBI) for cognitive profile between TBI and stroke.

	MMSE < 27	MMSE ≥ 27	Total
TBI			
MoCA < 26	70 (67.96%)	27[a] (26.21%)	97 (94.17%)
MoCA ≥ 26	2 (1.94%)	4 (3.89%)	6 (5.83%)
Total	72 (69.90%)	31 (30.10%)	103 (100%)
Stroke			
MoCA < 26	72 (56.69%)	38[a] (29.92%)	110 (86.61%)
MoCA ≥ 26	1 (0.79%)	16 (12.60)	17 (13.39%)
Total	73 (57.48%)	54 (42.52%)	127 (100%)

[a] Patients with normal MMSE but low MoCA.

Kappa value was 0.1314 with 95% *CI* (−0.0258, 0.2887). The sensitivity of MMSE to stroke was 57.48% while MoCA was 86.61%. The consistency test of two scales showed: Kappa value was 0.3103 with 95% *CI* (0.1749, 0.4456). In TBI group, 27 of 31 patients with normal MMSE score had abnormal MoCA score (MoCA < 26); in the stroke group, 38 of 54 patients (about 70.37%) with normal MMSE score had abnormal MoCA score (MoCA < 26).

In the TBI group, only 4 patients had normal scores in MoCA and MMSE. Equally, 99 patients had abnormal scores in MoCA and/or MMSE. In the stroke group, 16 patients had normal scores of MoCA and MMSE; 111 patients had abnormal scores in MoCA and/or MMSE. The general sensitivity of two scales was 87.40%.

Discussion

Epidemiologically, TBI and stroke vary significantly in risk factors, onset age and injured regions. Large epidemiological studies have indicated that most TBI victims were the youth and middle-aged adults,[20] while the peak onset age was old in patients with stroke.[21] In our research, statistical analysis also showed that the onset age of patients with TBI was significantly younger than that of patients with stroke.

The results indicate that the sensitivity of MoCA in the TBI group is better than that of MMSE. In both groups, a large portion of patients had normal MMSE scores but abnormal MoCA scores. In contrast, it was rare for patients to have normal MoCA but abnormal MMSE scores. We saw the poor consistency of two scales in both groups, which was resulted from their different focuses. MMSE allocates 24/30 points to recall, speech and orientation but just 1/30 point to visuoconstructive function. In comparison, MoCA has a wider coverage and is well balanced with every subtest. The visuospace, attention and executive function are assigned more points (14/30). The patients with stroke or TBI with mild cognitive impairment performed poorly in executive, analysis and visuospace missions but relatively normally in recall, speech and orientation missions which can be identified easily with MMSE but generally evade the screen with MMSE. These results are consistent with the studies of Alzheimer's Disease, stroke, transient ischemic attack, Parkinson disease, etc.[13–18,22]

The comparison of MoCA and MMSE in both groups indicates that the total scores are significantly different and patients with TBI tend to have lower total scores in two tests. The subtest scores of MoCA and MMSE showed TBI group has significantly lower scores in orientation and memory than stroke group. The result indicates the higher susceptibility of orientation and memory in TBI in comparison with stroke. The MoCA subtests are not of equal difficulty. The 5-word recall item produced the most errors across both groups, and a 'floor effect' of this task has been noted in studies of more cognitively impaired patients making it a poor discriminator in such patients.

Despite the younger age of onset, the cognitive disorders of the TBI group are generally severer than that of stroke group. The comparison of MoCA and MMSE in both groups indicates that their total scores are significantly different and patients with TBI tend to have lower total scores in two tests. The subtest scores of MoCA and MMSE show that the TBI group has lower scores in all subtests than stroke group, significantly different in orientation and memory. The result indicates that post-TBI cognitive impairment is more extensive and severer, especially the orientation and recall which might be the important nature differentiating the cognitive stroke impairment. The severance and extensiveness of post-TBI cognitive impairment may be mainly associated with lesion region. The lesion regions of TBI and stroke are different depending on their distinct mechanisms. Cortical lesions of frontal and temporal lobe etc as well as bilateral and diffusive injuries are common in TBI group compared with stroke group, which may explain the severer and more extensive cognitive impairments of patients with TBI. Inflictions in stroke group are mainly in basal ganglion region and cause more limited and milder cognitive impairments.

The results showed that patients in both groups had relatively low scores in some MMSE and MoCA subtests: calculation, writing and drawing subtests for MMSE; registration, naming, repetition, comprehension and reading subtests for MoCA. However, there were no significant differences in these subtests between two groups. Therefore, characteristics of post-stroke and TBI cognitive impairments may be similar in some aspects. It has been confirmed that executive function and recall were the most susceptible cognitive domains in mild patients with TBI.[4,23–25] The impairments of information processing and executive function are prominent in post-stroke patients with mild cognitive impairment.[26–28] Therefore, patients in both groups, especially those with moderate/severe cognitive impairment, had poor performance in subtests concerned with memory and executive function. No significant differences were found between two groups in subtests of attention, speech, abstract ability, calculation, executive function, etc. The exclusion of patients with severe dysphasia from our research may explain the insignificant difference in subtests concerned with speech. On the other hand, the weights of these subtests relative to total scores may be too small to present the differences fully.

Notably, patients in both groups have higher scores in MoCA in comparison with MMSE, mainly owing to their different emphasized domains. Due to the exclusion of patients with severe dysphasia, patients in two groups have relatively high scores in subtests concerned with speech. The weights of speech concerned subtests of MMSE are higher than those of MoCA (9/30 VS 3/30),[6,7] so patients have higher total score of MMSE than that of MoCA. The differentiations of subtests in two scales indicate that they are complementary and could be utilized combined in clinic to improve the identification of cognitive disorders significantly.

Patients in our research were recruited in rehabilitation center and most of them were severely injured in TBI or stroke. Therefore, the proportion of patients with moderate/severe was large and the sensitivity and differentiation of subtests of two scales may be affected. On the other hand, we excluded the patients incapable of cooperation for severe dysfunction of listening comprehension and oral expression.

Considering the percentage of speech evaluation in MMSE, the exclusion may influence the MMSE score. In addition, the similarities of two scales in some subtests content as well as the testing interval time and sequence may have affected the results.

Conclusion

Notably, impairments of cognition, especially orientation and recall function, may be severer and more extensive in TBI inpatients than stroke inpatients and thus demand the attention of clinicians. MoCA, as an easy-to-operated tool for cognitive impairment screen, can be used in TBI patients for its higher sensitivity. However, because two scales focus on different cognitive domains, we recommend combined application of both scales to optimize cognitive impairment screen and fully understand its characteristics. In the future, researches with large sample and follow up are needed to explore the differences between post-TBI and stroke cognitive impairments in influencing factors and effectiveness of rehabilitation.

Fund

This study was supported by the special basic research fund for Chinese central public research institutes (No. 2013CZ-30, 2013CZ-41).

References

1. Yang YC, Li SZ, Cheng XM, et al. Epidemiological survey of brain injury in six cities in China. *Chin J Neurosurg*. 1987;3:23–26.
2. Li SZ, Cheng XM, Wang WZ, et al. Epidemiological study on the diseases of the nervous system in Chinese rural areas. *Chin J Neurosurg*. 1989;5:2–6.
3. Brown AW, Leibson CL, Malec JF, et al. Long-term survival after traumatic brain injury: a population-based analysis. *NeuroRehabilitation*. 2004;19:37–43.
4. Arciniegas DB, Held K, Wagner P. Cognitive impairment following traumatic brain injury. *Curr Treat Options Neurol*. 2002;4:43–57.
5. Hukkelhoven CW, Steyerberg EW, Rampen AJ, et al. Patient age and outcome following severe traumatic brain injury: an analysis of 5600 patients. *J Neurosurg*. 2003;99:666–673.
6. Folstein MF, Folstein SE, McHugh PR. 'Mini-mental state'. A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12:189–198.
7. Nasreddine ZS, Phillips NA, Bédirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. 2005;53:695–699.
8. Wang ZY, Zhang MY. The application of the Chinese version of Mini-Mental State Examination. *Shanghai Arch Psychiatry*. 1989;7:108–111.
9. Wen HB, Zhang ZX, Niu FS, et al. The application of Montreal cognitive assessment in urban Chinese residents of Beijing. *Chin J Inter Med*. 2008;47:36–39.
10. Tombaugh TN, McIntyre NJ. The mini-mental state examination: a comprehensive review. *J Am Geriatr Soc*. 1992;40:922–935.
11. Mitchell AJ. A meta-analysis of the accuracy of the mini-mental state examination in the detection of dementia and mild cognitive impairment. *J Psychiatr Res*. 2009;43:411–431.
12. Lonie JA, Tierney KM, Ebmeier KP. Screening for mild cognitive impairment: a systematic review. *Int J Geriatr Psychiatry*. 2009;24:902–915.
13. Smith T, Gildeh N, Holmes C. The Montreal Cognitive Assessment: validity and utility in a memory clinic setting. *Can J Psychiatry*. 2007;52:329–332.
14. Pendlebury ST, Markwick A, de Jager CA, et al. Differences in cognitive profile between TIA, stroke and elderly memory research subjects: a comparison of the MMSE and MoCA. *Cerebrovasc Dis*. 2012;34:48–54. http://dx.doi.org/10.1159/000338905.
15. Pendlebury ST, Cuthbertson FC, Welch SJ, et al. Underestimation of cognitive impairment by Mini-Mental State Examination versus the Montreal Cognitive Assessment in patients with transient ischemic attack and stroke: a population-based study. *Stroke*. 2010;41:1290–1293. http://dx.doi.org/10.1161/STROKEAHA.110.579888.
16. Pendlebury ST, Mariz J, Bull L, et al. MoCA, ACE-R, and MMSE versus the National Institute of Neurological Disorders and Stroke-Canadian Stroke Network Vascular Cognitive Impairment Harmonization Standards Neuropsychological Battery after TIA and stroke. *Stroke*. 2012;43:464–469. http://dx.doi.org/10.1161/STROKEAHA.111.633586.
17. Nazem S, Siderowf AD, Duda JE, et al. Montreal cognitive assessment performance in patients with Parkinson's disease with "normal" global cognition according to mini-mental state examination score. *J Am Geriatr Soc*. 2009;57:304–308.
18. Hoops S, Nazem S, Siderowf AD, et al. Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. *Neurology*. 2009;73:1738–1745. http://dx.doi.org/10.1212/WNL.0b013e3181c34b47.
19. Crum RM, Anthony JC, Bassett SS, et al. Population-based norms for the Mini-Mental State Examination by age and educational level. *JAMA*. 1993;269:2386–2391.
20. Bruns Jr J, Hauser WA. The epidemiology of traumatic brain injury: a review. *Epilepsia*. 2003;44(suppl 10):2–10.
21. Xie SP, Zhao LJ, Liu Q. Epidemiological analysis of cerebrovascular disease in part areas of Beijing. *Chin J Epidemiol*. 1999;20:299.
22. Damian AM, Jacobson SA, Hentz JG, et al. The Montreal Cognitive Assessment and the mini-mental state examination as screening instruments for cognitive impairment: item analyses and threshold scores. *Dement Geriatr Cogn Disord*. 2011;31:126–131. http://dx.doi.org/10.1159/000323867.
23. Kwok FY, Lee TM, Leung CH, et al. Changes of cognitive functioning following mild traumatic brain injury over a 3-month period. *Brain Inj*. 2008;22:740–751.
24. Benedictus MR, Spikman JM, van der Naalt J. Cognitive and behavioral impairment in traumatic brain injury related to outcome and return to work. *Arch Phys Med Rehabil*. 2010;91:1436–1441. http://dx.doi.org/10.1016/j.apmr.2010.06.019.
25. Dikmen SS, Corrigan JD, Levin HS, et al. Cognitive outcome following traumatic brain injury. *J Head Trauma Rehabil*. 2009;24:430–438. http://dx.doi.org/10.1097/HTR.0b013e3181c133e9.
26. Sachdev PS, Brodaty H, Valenzuela MJ, et al. The neuropsychological profile of vascular cognitive impairment in stroke and TIA patients. *Neurology*. 2004;62:912–919.
27. Grau-Olivares M, Arboix A, Junqué C, et al. Progressive gray matter atrophy in lacunar patients with vascular mild cognitive impairment. *Cerebrovasc Dis*. 2010;30:157–166.
28. Passier PE, Visser-Meily JM, van Zandvoort MJ, et al. Prevalence and determinants of cognitive complaints after aneurysmal subarachnoid hemorrhage. *Cerebrovasc Dis*. 2010;29:557–563.