ORIGINAL ARTICLE

Association between working memory impairment and activities of daily living in post-stroke patients

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ABSTRACT

Aim Stroke is one of the leading causes of adult disability and functional impairment worldwide. Cognitive impairments including memory dysfunction are common after stroke and may have a negative impact to the functional status and activities of daily living (ADL). The study aimed to determine the impact of working memory impairment after stroke on ADL.

Methods This cross-sectional study involved post-stroke patients who underwent neurologic examination and mini mental state examination (MMSE), forward digit span (FDS) and backward digit span (BDS) to assess cognitive function, and assessment of daily life activities (ADL) and instrumental activities of daily living (IADL) scales.

Results This study included 38 patients, 23 (60.5%) males and 15 (39.5%) females. The mean MMSE, FDS and BDS scores were 24.60±4.49, 4.87±1.166 and 3.47±1.158, respectively. There were 17 (44.7%) patients with cognitive impairment (MMSE Score was lower than 24). The mean ADL and IADL scores were significantly higher in patients with cognitive impairment, showing greater dependency in this group of patients. There was a significant negative correlation between global cognitive function, working memory and ADL and IADL scores in post-stroke patients.

Conclusion Cognitive impairment has a negative impact on daily life activities in post-stroke patients.

Key words: cognition, function, quality of life, stroke

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Original submission:
24 January 2020;
Revised submission:
12 February 2020;
Accepted:
04 May 2020
doi: 10.17392/1135-20

Med Glas (Zenica) 2020; 17(2): 433-438

INTRODUCTION

Stroke remains a major healthcare problem and is the third leading cause of death after heart disease and cancer. Stroke is also a leading cause of functional impairments, with 20% of survivors requiring institutional care after 3 months, and 15-30% being permanently disabled (1). Stroke is considered a major cause of long-term physical disabilities in adults; it is the second most common cause of cognitive impairment and dementia (2). Physical impairments tend to improve, to a greater or lesser degree, following stroke; however, for reasons which remain unknown, cognitive impairments progressively worsen (3). Several studies have shown that cognitive impairment might have a negative effect on functional outcome and activities of daily living (ADL) (2,4,5). The occurrence of cognitive impairment among post-stroke patients was high. Multiple cognitive domains are affected and this may hamper recovery and negatively impact independence and quality of life after stroke (5). Cognitive impairment may also lead to decreased functional capacity and thus affect rehabilitation outcome in stroke. Paker et al. reported that cognitive dysfunction interfered with community ambulation in patients with stroke, but did not have a significant effect on ADL and global recovery (6).

Stroke mainly affects attention and executive function, but may also impair memory function, mainly working memory and episodic memory (2,7). Post-stroke memory dysfunction (PMD) is a prerequisite for the diagnosis of post-stroke dementia. The prevalence of PMD varied from 23-55% in the three-month post-stroke period. Larger stroke volume, pre-stroke medial temporal lobe atrophy, and white matter lesions were related with decreased post-stroke memory function (7). A deficit in working memory also negatively impacts post-stroke physical rehabilitation. Malouin et al. studied the relationship between working memory and motor improvement in post-stroke patients and found that working memory correlated significantly with the level of improvement. Their result suggested that the functional outcome after practice depended on the ability to maintain and manipulate information in working memory (8).

The magnitude of stroke makes it important for patients and their families to be aware of their future possibilities and factors associated with rehabilitation not only physical but also cognitive and psychological. Other than global cognitive function, working memory has also been found to be related to functional outcome and might affect physical rehabilitation and the quality of life subsequently (9). Post-stroke cognitive impairment can be assessed through neuropsychological assessments that ideally are able to cover all cognitive domains, including working memory (10). However, in clinical practice setting, the brevity of this neuropsychological assessment should also be taken in consideration (11).

The study aimed to determine the impact of global cognitive and working memory impairment after stroke on daily life activities.

PATIENTS METHODS

Patients and study design

This cross-sectional study involved 38 post-stroke patients who were recruited from the Memory Clinic, Neurology Department of the Adam Malik General Hospital Medan, North Sumatera, Indonesia, between April and June 2018. Inclusion criteria were: age equal or more than 18 years, history of stroke for more than three months to two years, modified Rankin scale score <3, compos mentis and fully cooperative, speak Bahasa Indonesia fluently, able to read and write, and gave written consent to be included in the study. Exclusion criteria were: patients who were medically unstable (delirium) or had other psychiatric disorders, had an aphasia and history of dementia before stroke.

All patients underwent physical and neurologic examination.

The Health Research Ethical Committee of the Medical Faculty of Universitas Sumatera Utara/H. Adam Malik General Hospital approved this study.

Methods

Cognitive function was evaluated using mini mental state examination (MMSE), forward digit span (FDS) and backward digit span (BDS). The MMSE, which consisted of 6 subscales (orientation, registration, attention, calculation, recall, language) and praxis test, was used to assess global cognitive function, to estimate the severity of cognitive impairment and to classify patients as having a clinical level of cognitive impairment (12): patients with cognitive impairment - the

MMSE score <24, and patients with normal cognitive function – the MMSE score ≥24.

Measures of forward (FDS) and backward digit span (BDS) are among the oldest and most widely used neuropsychological tests of short-term verbal memory (13).

Digit span was measured for forward and reverse-order (backward) recall of digit sequences. In the forward condition, sequences of digits of increasing length have to be repeated in the same order as presented. In the backward condition, digit sequences have to be repeated in reverse order (14). Digit sequences are presented beginning with a length of two digits, and two trials are presented at each increasing list length. Testing ceases when the patient fails to accurately report either trial at one sequence length or when the maximal list length is reached (9 digits forward, 8 backward) (13).

The ability to perform activities of daily living was assessed using two scales: Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL).

The ADL scale is a career-rated instrument consisting of six daily-living abilities, including basic tasks of personal care in everyday life, e.g. bathing, continence, transfers, feeding, dressing and transferring. For this study, questionnaire responses were made on to a Likert scale (15) ranging from 0 (independent) to 2 (completely dependent) (16).

The Instrumental Activities of Daily Living (IADL) scale measures the activities related to independent living. It is a career-rated instrument consisting of seven daily-living abilities including items related to using the telephone, preparing meals, taking medicine, traveling, shopping for groceries or personal items, performing light or heavy housework and managing money. In a similar way to the ADL, every activity is rated on a scale that includes three choices: person is independent, person requires assistance and person is completely dependent on others. For this study, the questionnaire responses were made using a Likert scale ranging from 0 (independent) to 2 (completely dependent) (17).

Statistical analysis

The Spearman correlation to measure the correlation between MMSE scores and ADL and IADL was used. Statistical significance was assumed at <0.05.

RESULTS

This study included 38 patients, 23 (60.5%) males and 15 (39.5%) females. The mean age was 58.8±10.38 years.

The mean MMSE score was 24.60±4.49. There were 17 (44.7%) patients with cognitive impairment (the MMSE score <24), and 21 (55.3%) patients with normal cognitive function (the MMSE score ≥24). There were no significant differences on demographic characteristics and stroke risk factors between the patients with cognitive impairment and those who were cognitively intact (Table 1).

Table 1. Clinical characteristics of the patients

Variable	No (%) of patients in the group: Cognitively normal group (n=21)	Cognitive impairment group (n=17)	Total (n=38)	p
Gender				0.847
Male	13 (61.9)	10 (58.8)	23 (60.5)	
Female	8 (39.1)	7 (41.2)	15 (39.5)	
Age (mean±SD) (years)	59.82±9.14	57.50±12.06	58.84±10.38	0.524
Age group (years)				0.775
<45	1 (4.8)	1 (5.9)	2 (5.3)	
46-50	3 (14.3)	3 (17.6)	6 (15.8)	
51-55	3 (14.3)	2 (11.8)	5 (13.2)	
56-60	4 (19.0)	5 (29.4)	9 (23.7)	
61-65	3 (14.3)	4 (23.5)	7 (18.4)	
66-70	4 (19.0)	0 (0.00)	4 (10.5)	
71-75	2 (9.5)	1 (5.9)	3 (7.9)	
>75	1 (4.8)	1 (5.9)	2 (5.3)	
Educational level				0.403
Primary	1 (4.8)	3 (17.6)	4 (10.5)	
Junior high school	3 (14.3)	1 (5.9)	4 (10.5)	
High School	12 (57.1)	4 (23.5)	16 (42.1)	
Diploma	1 (4.8)	1 (5.9)	2 (5.3)	
University	4 (19.0)	8 (47.1)	12 (31.5)	
Occupation				0.747
Employee	7 (33.3)	7 (41.2)	14 (36.8)	
Housewife	4 (19.0)	2 (11.8)	6 (15.8)	
Entrepreneur	6 (28.6)	1 (5.9)	7 (18.4)	
Farmer	0	1 (5.9)	1 (2.6)	
Unemployed	4 (19)	6 (35.3)	10 (26.3)	
Stroke aetiology				0.878
Ischemia	20 (95.2)	16 (94.1)	36 (94.7)	
Haemorrhage	1 (4.8)	1 (5.9)	2 (5.3)	
Hypertension				0.426
Yes	20 (95.2)	15 (88.2)	35 (92.1)	
No	1 (4.8)	2 (11.8)	3 (7.9)	
Diabetes mellitus				0.578
Yes	8 (38.1)	8 (47.1)	16 (42.1)	
No	13 (61.9)	9 (52.9)	22 (57.9)	
Atrial fibrillation				0.828
Yes	1 (4.8)	1 (5.9)	2 (5.3)	
No	20 (95.2)	16 (94.1)	36 (94.7)	
Coronary heart disease				0.239
Yes	2 (9.5)	4 (23.5)	6 (15.8)	
No	19 (90.5)	13 (76.5)	32 (84.2)	

The FDS (p=0.0124) and BDS (p=0.026) scores were significantly higher in patients with normal cognitive function, 5.29±1.007 and 4.00±1.304, respectively, comparing to the patients with impaired cognitive function, 4.35±1.169 and 2.82±1.704, respectively.

Mean scores of ADL (p=0.001) and IADL (p=0.001) were significantly lower in the patients without cognitive impairment, 0.19±0.512 and 0.38±1.071, respectively, showing that patients with normal cognitive function were more independent than those who were cognitively impaired, 3.29±3.19 and 5.41±5.06, respectively (Table 2).

Table 2. Activities of daily living (ADL) and instrumental activities of daily living (IADL) scores of post-stroke patients with and without cognitive impairment

Variable	Mean±SD			p
	Cognitively normal group (n=21)	Cognitive impairment group (n=17)	Total (n=38)	
FDS	5.29±1.007	4.35±1.169	4.87±1.166	0.0124
BDS	4.00±1.304	2.82±1.704	3.47±1.158	0.026
ADL	0.19±0.512	3.29±3.19	1.58±2.647	0.001
IADL	0.38±1.071	5.41±5.06	2.63±4.258	0.001

FDS, forward digit span; BDS, backward digit span;

There was a significant positive correlation between global cognitive function (MMSE score) and working memory function, FDS (r= 0.620) and BDS (0.536) (p<0.001). There was a significant negative correlation between each cognitive score (MMSE, FDS and BDS) with ADL and IADL scores (p=0.005 and p=0.010, respectively). Higher scores on cognitive assessment showed better cognitive function related to lower scores on ADL and IADL scales, e.g. the patients were more independent (Table 3)

Table 3. Correlation between working memory and activities of daily living (ADL) and instrumental activities of daily living (IADL)

Cognitive scores	ADL		IADL	
	r	p	r	p
MMSE	-0.772	<0.001	-0.757	<0.001
FDS	-0.430	0.007	-0.443	0.005
BDS	-0.362	0.026	-0.413	0.010

MMSE, mini mental state examination; FDS, forward digit span; BDS, backward digit span;

DISCUSSION

Our data have shown a negative association between cognitive function and activities of daily living in post-stroke patients: the patients with better cognitive function had better performance on daily life activities. This is in line with several previous studies. Ferreira et al. have shown that the presence of neuropsychological impairment could affect the functional abilities in post-stroke patients, particularly the IADL (5). Orso et al. studied 75 post-stroke patients and found that cognitive dysfunction had a strong impact on ADL dysfunction (6). Park et al. found that post-stroke cognitive impairment without dementia also interfered with health-related quality of life (19). Cognitive impairment has also been reported to be associated with post-stroke rehabilitation. Deficits in working memory (ability to hold information in mind temporarily) caused by stroke can present a significant barrier to independence (9). Malouin et al. reported that working memory negatively correlated with the level of improvement, suggesting that functional outcome after practice depended on the ability to maintain and manipulate information in working memory (8). Although a study by Paker et al. did not find any statistically significant difference in the functional status improvement between stroke patients with and without cognitive impairment, the community ambulation rate was higher in cognitively normal group at the sixth month visit (6). Our study did not investigate this relationship further, but the Modified Rankin Scale score (MRS) score in our study was lower than 3, meaning the patients had only minimal symptoms and mild to moderate physical disability (able to walk without assistance).

After stroke, the most prominent impairment can be recognized in the patient's processing speed, attention, and executive function. (10) Post-stroke dementia, particularly vascular dementia, causes slowing in cognitive flexibility, perceptual disorder, and impairment information retrieval at the time of stroke diagnosis. Up to 20-50% of stroke patients suffer from the memory problem that manifests during a period following the stroke diagnosis (2).

There were 17 patients (44.7%) patients with cognitive impairment in our study. This proportion is similar to the result from a previous study by Ferreira et al. that reported a proportion of 37.8% patients with cognitive impairment in post-stroke patients (5).

Post-stroke cognitive dysfunction spectrum is determined by the size and location of the infarction, but there is no clear indication on the presence of memory dysfunction due to stroke mainly episodic since it is believed that almost never an infarction in the medial temporal lobe, brain structure is predominantly involved in memory encoding and retrieval (7,18).

This study showed that FDS and BDS scores were higher in cognitively normal group compared to the group with cognitive impairment. Our results showed that a higher MMSE score is also associated with a better performance on working memory tasks. This is consistent with previous studies that reported higher scores of all cognitive domains in patients with normal cognitive function compared to cognitively impaired post-stroke patients (4,5). The highest impact of stroke at the time of diagnosis is on the attention and executive function rather than on memory, which may be impaired at various post-stroke intervals, but memory dysfunction are also common after stroke (2).

Cognitive impairment, particularly memory problems following a stroke, can be evaluated and assessed through neuropsychological assessments. Clinically, different neuropsychological assessments are used to assess cognitive dysfunction in terms of cognitive domain: memory evaluation is proposed to be associated with memory types, short-term memory and working memory refer to the perceptual and learning areas of the cognitive domain, which are processed by the frontal lobe (2). Working memory is the ability to maintain and manipulate information for a brief period of time. The model consists of two slave systems: the phonological loop for verbal information and the visuospatial sketchpad for visual and spatial information. The capacity of the phonological loop is typically assessed using digit span tasks, while the visuospatial sketchpad can be assessed using spatial span tests. Both working memory components function under the control of the central executive, which is recruited under higher memory loads (14). Our study used MMSE and digit span to assess working memory. Subtest of MMSE can assess attention and concentration (by serial subtraction), verbal memory (repetition of sentences) and visuospatial (2 pentagons drawing). Digit span can assess attention, concentration and mental control (2,13,14).

Based on stroke location and severity, memory disorder may occur for one or more memory types, eventually ending in memory decline and loss (2). Working and episodic memory were found to be more regularly diminished in stroke victims (18). Memory is now considered as relying on the interplay of a number of interacting components. Working memory, also labelled short-term memory, is involved in the on-line maintenance and active manipulation of information; it is generally conceived as a multicomponent system, which relies on a complex network of brain areas including temporo parietal and frontal areas.

It is postulated to include an attentional control component, the central executive, as well as stores involved in the short-term maintenance of material of different natures (8). The emergence of post-stroke memory dysfunction fits in current thinking of memory as a function of an intact cerebral network, connecting several parts of the brain, including medial temporal lobes, anterior thalamic nucleus, mammillary body, fornix, and prefrontal cortex with each other (the so-called circuit of Papez). Any stroke in either of these structures or in the connections in between could result in PMD (7).

Assessing the level of working memory impairment in post-stroke patients may improve a rehabilitation plan. Approaches to enhancing memory may aim to reduce distraction, or increase efficiency of encoding and retrieval (9).

This study had several limitations. The sample size was relatively small, so the result cannot be generalized to all post-stroke patients. Also, we did not analyse the stroke type, location and severity that could affect the cognitive function, although we had excluded patients with aphasia and history of prior dementia.

In conclusion, post-stroke cognitive impairment, particularly deficit in working memory may negatively affect daily life activities. This result is important because cognitive dysfunction after stroke has implications for rehabilitation and treatment strategies.

FUNDING

This research is funded by Research Institute Universitas Sumatera Utara according to Research Contract TALENTA Universitas Sumatera Utara (No: 2590/UN5.1.R/PPM/2018; March 16th 2018).

TRANSPARENCY DECLARATION

Conflicts of interest: None to declare.

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