Published in final edited form as:
Neuropsychol Rehabil. 2013 April ; 23(2): 256–266. doi:10.1080/09602011.2012.748672.

Changes in Cognition Following Mild Stroke

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Abstract

The objective of this study was to determine how performance on cognitive assessments administered in the subacute phase of mild stroke change or remain stable over time. This was a prospective longitudinal cohort pilot study with participants with mild stroke (n = 20). Cognitive status was assessed at two time points: (1) within three-weeks post-discharge from the acute care setting following mild stroke; and (2) approximately 6 months post-mild stroke. Participants were given a battery of cognitive assessments at both time points that included the following measures: (1) Short Blessed Test; (2) California Verbal Learning Test (CVLT); (3) Connor's Continuous Performance Task (CPT); and (4) The Delis-Kaplan Executive Function System (DKEFS) Trail Making subtest. The only significant differences between the test administrations was on the CVLT Short Delay Free Recall (p=.027) and Long Delay Free Recall (p=.002) which was likely due to practice effects associated with this measure. The results of this study show that performance on standardized cognitive testing in the early phases of mild stroke remained stable over a 6-month period. These results help justify the necessity and ability to assess cognition immediately post-mild stroke in order to make accurate and appropriate rehabilitation recommendations.

Keywords

Stroke; Cognition; Executive Function; Neuropsychological Tests; Rehabilitation

Introduction

Today there are over 4.8 million stroke survivors in the United States, and approximately 266,000 of them have a permanent disability as a result of their stroke (American Heart Association, 2010). As knowledge about the medical management of stroke continues to improve, so do survival rates which means more people today are living with chronic deficits post-stroke than are dying from them(Clarke, 1999). This presents a new challenge for rehabilitation services in regards to how to best meet these patient's needs.

While rehabilitation in the acute care setting is effective in assessing a patient's level of physical dysfunction and self-care needs immediately post-stroke, little attention is being given in regards to addressing the level of cognitive impairment. The standard post-stroke rehabilitation protocol in most hospitals includes assessments that are geared towards diagnosing physical dysfunction. Three of the most common assessments are the National

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The authors have no financials conflicts of interest to report related to this study.

Institutes of Health Stroke Scale (NIHSS), the Functional Independence Measure (FIM), and the Barthel Index. The NIHSS measures neurological deficits across eleven categories including paralysis, speech difficulties, sensory loss, and visual impairments(Brott, et al., 1989). The FIM is an eighteen item ordinal scale that is used to measure a person's ability to function independently after discharge from the rehabilitation setting (Keith, Granger, Hamilton, & Sherwin, 1987). The Barthel Index measures a patient's ability to physically perform various activities of daily living (Barthel & Mahoney, 1965). These assessments have been shown to be biased toward the assessment of physical disability and have very limited utility in regard to evaluating cognitive domains (e. g. , executive function) that may impede the patient's ability to return to previous levels of participation in everyday life (Hajek, Gagnon, & Ruderman, 1997). Longitudinal studies have shown that the long-term progression of cognitive function post-stroke can change over time (Tham, et al., 2002); however, there are no established methodologies/assessments for identifying those patients that will experience a change in their cognitive abilities before they are discharged home from the acute care setting (del Ser, et al., 2005). This is especially problematic for the mild stroke population.

The age and neurological severity of stroke are significantly decreasing(Black-Schaffer & Osberg, 1990; Vestling, Tufvesson, & Iwarsson, 2003; P. A. Wolf, et al., 1992; T. J. Wolf, Baum, & Connor, 2009). Most of the literature about cognition after stroke has focused on moderate to severe strokes with little research being done on the mild stroke population since they are expected to make a full recovery independent of rehabilitation services (D. F. Edwards, et al., 2006). A mild stroke is defined as a NIHSS score of <6 and has been found to represent as much as 49% of the population seen in the acute care stroke setting (T. J. Wolf, et al., 2009). The mild stroke population presents a new challenge for rehabilitation specialists because their primary deficits are more subtle (i. e., cognitive dysfunction) as opposed to typical stroke symptoms which are more overt (i. e., hemiparesis). A study done by the Cognitive Rehabilitation Research Group at Washington University School of Medicine on mild stroke survivors showed that executive dysfunction is present in 30–60 percent of the mild stroke population (T. J. Wolf, Barbee, & White, 2010). However, despite this fact the majority of mild stroke patients are discharged home without a referral to rehabilitation services (Tellier & Rochette, 2009).

Cognitive dysfunction after mild stroke can severely impact an individuals' ability to function in everyday life and perform meaningful occupations (Edwards, Hahn, Baum, & Dromerick, 2006; Rochette, Desrosiers, Bravo, St-Cyr-Tribble, & Bourget, 2007; T. J. Wolf, et al., 2009). Longitudinal studies have shown that if cognitive dysfunction is present it persists into the chronic phases of mild stroke (D. Edwards, et al., 2006; Rochette, et al., 2007) and as a result, individuals with mild stroke are experiencing difficulty returning to work and participating in other everyday life activities. Edwards and colleagues found that individuals with mild stroke often experience changes in work, driving, and recreational activities due to cognitive dysfunction in the six months following mild stroke (D. Edwards, et al., 2006). Rochette and colleagues found a significant decrease in social roles and responsibilities and satisfaction with personal relationships following mild stroke (Rochette, et al., 2007). O'Brien and Wolf found that 46% of mild to moderate stroke survivors who were working prior to their stroke were unemployed at six-months post-stroke and of those survivors who did return to work, 56% reported performing at 75% or less of their previous work ability (O'Brien & Wolf, 2010). Cognitive deficits need to be identified initially post-stroke and regularly monitored in order to prevent poor functional outcomes and decreased quality of life in patients with mild stroke.

Given what we know about how cognition is affected after mild stroke, cognition is still rarely, if ever, assessed in the mild stroke population in the acute or subacute phase of stroke. The reason why cognitive dysfunction is often not assessed post-mild stroke is due to the notion that deficits identified would likely resolve over time on their own (Steven, 2008); meaning any assessment completed in the acute phase of stroke would not be valid because regardless of the individual's performance on the assessment at that time he/she would likely improve over time. This concept, known as spontaneous recovery, permeates stroke rehabilitation and is not unique to cognitive dysfunction. Spontaneous recovery has been shown to occur widely post-mild stroke and it has been suggested that the greatest improvements that can be expected are in the domains of executive function, aphasia, and long-term memory (Lesniak, Bak, Czepiel, Seniow, & Czlonkowska, 2008). Further, one study found that 16–20 percent of people who have cognitive dysfunction after stroke have complete recovery of cognitive deficits within three months (Rasquin, Lodder, & Verhey, 2005) and additional studies have showed that executive dysfunction is one of the fastest-recovering cognitive processes in the first year following a stroke(Lesniak, et al., 2008; Rochette, et al., 2007). While it is known that cognitive deficits post-stroke, especially executive dysfunction, can spontaneously recover in the months following a stroke, research with the mild stroke population that has identified cognitive impairments and participation deficits in longitudinal follow-up studies contradict this notion. The objective of this study was to determine how performance on cognitive assessments administered in the subacute phase of mild stroke change or remain stable over time.

Design and Methods

Design

This was a prospective longitudinal cohort pilot study that measured cognitive status at two time points: (1) on average within three weeks post-discharge from the acute care setting following mild stroke; and (2) approximately six months post-mild stroke. Participants were given the same battery of cognitive assessments at both time periods so that changes in scores on the cognitive measures could be monitored. This study was reviewed and approved by the Washington University Human Research Protection Office.

Participants

Participants (n = 20) were recruited from the Cognitive Rehabilitation Research Group (CRRG) stroke registry, which registers individuals who are seen by the Barnes-Jewish Hospital (BJH) Stroke Service in Saint Louis, Missouri. All stroke patients who are seen by the stroke service at BJH is asked to be a part of the stroke registry. Participating in the registry means that the individual is allowing their acute hospital data to be used for research purposes and also giving permission to members of the Washington University School of Medicine community who are associated with the registry to contact them for future studies. In order to participate in this study, individuals in the registry had to meet additional inclusion/exclusion criteria which are as follows: **Inclusion criteria:** (1) mild stroke as diagnosed by a physician (National Institutes of Health Stroke Scale score of <6); (2) and aged 18–65. **Exclusion criteria:** (1) history of any other neurological disorder prior to stroke; (2) history of mental illness prior to stroke; (3) history of previous stroke; (4) diagnosis of dementia; and (5) pre-morbid Barthel Index (ADL function) of <95. All participants selected from the CRRG Stroke Registry consented and gave permission to be contacted for future studies.

Methods

All testing was completed at the Program in Occupational Therapy at Washington University School of Medicine in Saint Louis, Missouri. All personnel were trained before giving the assessment batteries to ensure internal validity and reliability. Participants were recruited over the phone to come in for initial testing. Once informed consent was obtained, participants completed the cognitive assessment battery (see outcome measures below). At six months, participants were contacted again and asked to come back in for testing and the cognitive measures were re-administered. Study data were collected and managed using REDCap electronic data capture tools hosted at Washington University in Saint Louis School of Medicine. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources (Harris, et al., 2009).

Measures

General cognitive status

The Short Blessed Test (SBT): The SBT is a cognitive screening test measuring orientation and memory designed to be sensitive to discriminating between mild, moderate and severe cognitive impairments. In a study that used the SBT as a screen to predict performance on a full cognitive assessment (The Mental Status Questionnaire), the SBT was shown to have strong reliability and consistency with the full Mental Status Questionnaire (multiple r=.941, r^2=.886). Approximately 90% of SBT scores were within ±4 of the actual full score values of the Mental Status Questionnaire indicating that the SBT has good predictive validity of cognitive impairments (Katzman, et al., 1983). The total number of errors was used in the analysis.

Memory

California Verbal Learning Test (CVLT): The CVLT is a well-established neuropsychological test of verbal memory. The immediate and delayed recall measures will be used for this study. The CVLT has been shown to have large test-retest correlation coefficients for the primary CVLT measures in both the standard/standard (range=0.80–0.84) and standard/alternate (range=0.61–0.73) cohorts. Small practice effects (Cohen's *d* range=−0.01 to 0.18) and test re-test reliability have been noted for the general adult population, making it a useful assessment in longitudinal studies (Woods, Delis, Scott, Kramer, & Holdnack, 2006). Standard z scores for the CVLT are based on a scale of 0 with a standard deviation of 1 (range −5 to 5). These scores yielded a very narrow range of observations that a Shapiro-Wilk test indicated to be not normally distributed. Therefore, since the aim of the study was to look at performance over time and not make any comparisons between heterogeneous populations the following raw scores were used in the analysis: (1) free recall of List A following a single presentation (Trial 1); (2) free recall of List A following five presentations (Trial 5); (3) free recall of List B (a novel second list of words) (List B); (4) free recall of List A following a short delay (Short-Delay); and (5) free recall of List A following a long delay.

Attention

Connor's Continuous Performance Task (CPT): The CPT is a psychological test which measures sustained/selective attention and impulsivity. It has been normed on adults with neurological impairments and has split-half reliability and validity as it has satisfactory accuracy in terms of both false negatives and false positives (Connor & Lyon, 2009). Internal consistency and intraclass correlation for interrater and test re-test reliability were examined, yielding high interrater reliability (r=0.98) and internal consistency (r=0.95). CPT scores correlated with the Mini-Mental State Examination (r=0.88). Predictive validity was based on total score correlation of 0.78 with the Self-Care Performance Test (Burns, Mortimer, & Merchak, 1994). The number of omissions and commissions were used in the analysis.

Executive Function

Delis-Kaplan Executive Function System (DKEFS): The DKEFS is the only scaled executive function battery available. It has 9 stand-alone tests that can be administered independently to assess various aspects of executive function. The Trail Making subtest was used in this study. It was normed on participants ages 8–89 and has test-retest and total score reliability of r=0.66 for the Trail Making subtest (Delis, Kaplan, & Kramer, 2001). Conditions 4 and 5 of the Trail Making Test were used in the analysis. Condition 4 of the Trail Making Test (Number-Letter Switching) is the condition specifically designed to assess executive function; the other conditions are meant to evaluate deficits in sequencing, visual scanning, and motor speed (Yochim, Baldo, Nelson, & Delis, 2007).

Analysis

Raw data were cleaned and descriptive statistics were compiled to describe the population. Paired-samples t-tests were used to compare initial cognitive testing results to the follow-up cognitive testing results for all of the outcome measures for all of the participants. Additional paired-samples t-tests were used to compare the initial and follow-up executive function (DKEFS) results for just the individuals who scored greater than one standard deviation below the mean (less than 7) on DKEFS Trail Making Condition 4 (n = 8).

Results

A description of the sample is presented in Table 1 below. Individuals with a NIHSS score of 0 were included in this study because they had a stroke diagnosis by their physician. The NIHSS is administered between 24–72 hours post-stroke. Given the nature of the neurological deficits seen following mild stroke, it is possible for these individuals' stroke symptoms to mostly resolve before the NIHSS is administered. In addition to the variables in the table the following data were also collected: (1) 50.0% of the sample was Caucasian, 50.0% were African American; (2) the entire group was discharged home with 35.0% receiving no rehabilitation services, 60.0% receiving outpatient services, and the remaining 5.0% receiving in-home services only; (3) 55.0% of the group was female; (4) 30.0% had a right hemisphere stroke, 15.0% left hemisphere, 15.0% bilateral, and 40.0% were unspecified; and (5) 20.0% had a hemorrhagic stroke. Initial testing occurred approximately three weeks after stroke (21.95 SD 10.68) and follow-up testing occurred approximately six-months post-stroke (178.50 SD 47.90).

The results of the paired samples t-tests comparing the initial cognitive testing scores with the follow-up testing scores are listed in Table 2 below. The only significant differences were found with the CVLT in the Short Delay Free Recall and Long Delay Free Recall trials. For all the other tests, the changes between the initial testing and follow-up testing were insignificant at the $p<.05$ level. With the exception of the CPT Commissions score, the correlation coefficients between test administrations on all of the assessments were very high (.475–.937).

Finally, results of a paired-samples t-test comparing the scores from the initial testing and the follow-up testing on the DKEFS Trail Making Test (Condition 4) with just the individuals who scores greater than one standard deviation below the scaled score mean (n = 8) showed no significant difference between test administrations (p = .629). Overall, performance did not improve much from initial testing (4.75 SD 4.20) to follow-up testing (4.00 SD 2.27).

Discussion

The results of this study showed that there were almost no statistically significant differences between the initial cognitive testing completed during the subacute phase of mild stroke and the follow-up testing completed in the chronic phase of mild stroke. The only significant differences were on the CVLT Short Delay Free Recall and CVLT Long Delay Free Recall where participants overall improved their scores between test administrations. While the reason for this improvement is not clear from the data obtained in this study, it is likely due to a practice effect associated with this measure. Previous research has shown that prior exposure to word list can have a positive effect on future performance even in populations with known cognitive dysfunction (Hawkins & Wexler, 1999). Future studies should select a different measure of memory function that does not include multiple serial repetitions of word lists. Overall, however, the relative stability in performance on the cognitive assessment battery in this study provides initial support for the ability and necessity of testing cognitive function in the early phases of mild stroke. More thorough cognitive testing in the early phases of mild stroke is essential so patients receive appropriate referrals to rehabilitation services in order to maximize functional gains. These results further support previous research which has shown that cognitive dysfunction in this population can become chronic and often deficits are present acutely but not identified (D. Edwards, et al., 2006; T. J. Wolf, et al., 2010). Without early identification of cognitive deficits, individuals with mild stroke can experience poor outcomes in complex everyday life activities, such as work and driving (D. Edwards, et al., 2006; O'Brien & Wolf, 2010; Rochette, et al., 2007).

A limitation of this study is that the stroke sample was small and overall very homogeneous. While this made the study more representative of the stroke population that would likely be encountered in the acute hospital setting, the results of this study could have been confounded by a high percentage of persons who did not have cognitive deficits and consistently performed well on the cognitive assessment battery. This limits the generalizability of the findings of this study. The goal of this preliminary study was to test a sample of the population seen in the acute care setting to see how performance on measures of cognition would change over time; the focus was not to identify deficits. The justification for this study was to contradict the notion that however the participants scored during the subacute phase of stroke that their scores on the cognitive measures would improve over time. While overall the participants in this study performed well on the assessments, they did not perform at ceiling level and could have hypothetically performed better at 6-months. The subgroup analysis with the people in this study who scored poorly (greater than one standard deviation below the mean scaled score) on the executive function measure (DKEFS Trailmaking: Condition 4) (n = 8) contradict this notion given that their performance on this measure did not improve between test administrations; however, future studies need to account for this factor by specifically identifying individuals with cognitive dysfunction following mild stroke and serial testing cognitive performance over time.

Another limitation of this study was the single-group design. The focus of this preliminary study was specifically on individuals with mild stroke because often cognitive dysfunction is their primary limiting deficit following stroke that needs to be identified. Future studies should however look at the differences in cognitive performance over time between mild, moderate, and severe stroke to determine how the findings of the study apply across levels of impairment following stroke.

Acknowledgments

This study was funded by the National Institute of Child Health and Human Development / National Institute Neurological Disorders and Stroke, National Institutes of Health (K12 HD055931).

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Table 1

Description of the study sample (n=20)

Variable	Range	Mean	Standard Deviation
Age	34–64	52.15	7.43
Years of Education	10–20	14.45	2.63
Total NIHSS	0–5	1.35	1.35
WTAR Standard Score	69.00–126.00	102.25	16.78

Table 2

Paired samples t-tests between initial (1) and follow-up testing (2)

Assessment	Mean (SD)	P	r
Short Blessed 1 Short Blessed 2	1.50 (1.99) 1.80 (3.47)	.643	.572
CPT- Omissions 1 CPT- Omissions 2	67.71 (78.63) 60.26 (49.83)	.384	.937
CPT- Commissions 1 CPT- Commissions 2	47.26 (6.71) 46.43 (8.67)	.710	.254
CVLT-Trial 1-1 CVLT-Trial 1-2	5.75 (1.71) 6.45 (2.28)	.153	.475
CVLT-Trial 5-1 CVLT-Trial 5-2	12.25 (3.24) 11.40 (2.80)	.108	.731
CVLT-Trial B-1 CVLT-Trial B-2	4.60 (1.93) 4.95 (2.06)	.433	.523
CVLT- Short Delay Free Recall 1 CVLT- Short Delay Free Recall 2	9.65 (3.31) 10.70 (3.84)	.027*	.860
CVLT- Long Delay Free Recall 1 CVLT- Long Delay Free Recall 2	10.75 (3.64) 12.45 (3.15)	.002*	.826
DKEFS- Trail Making Condition Four 1 DKEFS- Trail Making Condition Four 2	8.45 (4.08) 8.95 (4.45)	.415	.806
DKEFS- Trail Making Condition Five 1 DKEFS- Trail Making Condition Five 2	9.90 (1.97) 10.10 (2.10)	.464	.829