The Impact of Cognitive Impairment on Functional Abilities of Stroke Patients

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2010
بسم الله الرحمن الرحيم

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ربّ أُوزُمِنِيْ آنْ أَشْكُرُ بِعَفْمَتِكَ الْثِّيْسِ أَنْعَفْتَ عَلَى وَ عَلَى وَالْحَيٍّ وَأَنْ أَعْمَلُ حَالِيَّاً تُرْضِيَ عَلَى وَ أَحْبَابِي وَرَفْعِيْتُكَ في عَبَاحِكَ الْمَلَائِيْمَ

صدق الله العظيم

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Yasmine Sabry

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The purpose of this study was to investigate the impact of cognitive impairment on functional abilities of stroke patients. Thirty stroke patients were selected for this study, 15 patients with right Cerebro-Vascular Accident [CVA] (group A), and 15 patients with left CVA (group B). Their ages ranged from 45 to 60 years and the duration of illness ranged from three to 18 months. Cognitive functions were evaluated using RehaCom and Mini Mental State Examination (MMSE), while functional abilities were evaluated using Barthel Index (BI) for both groups. 15 normal subjects (group C) matched in age were also included as a control group. The cognitive functions of this group were evaluated by RehaCom and the obtained values were compared to that of stroke patients. The results of study revealed that patients who had highly cognitive impairment suffered from functional disabilities which vary in degree according to the severity of cognitive impairment, beside, cognitive impairment associated with right hemispheric vascular accident are more devastating than that associated with left hemispheric accident. Consequently, patients with right CVA suffered more functional decline. In conclusion: cognitive impairment in stroke patients especially those with right hemispheric lesions had an impact on functional abilities of such patients.

Key words: Cognitive functions, Functional abilities, Stroke.
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<td>Activities of Daily Living</td>
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<td>BI</td>
<td>Barthel Index</td>
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<td>CT</td>
<td>Computerized Tomography</td>
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<td>CVA</td>
<td>Cerebro-Vascular Accident</td>
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<td>FIM</td>
<td>Functional Independence Measure</td>
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<td>FSIQ</td>
<td>Full Scale Intelligence Quotient</td>
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<td>Neuropsychological Assessment Batteries</td>
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<td>PIQ</td>
<td>Performance Intelligence Quotient</td>
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<td>RNAO</td>
<td>Registered Nurse Association of Ontario</td>
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<tr>
<td>TIA</td>
<td>Transient Ischemic attack</td>
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<td>VCI</td>
<td>Vascular Cognitive Impairment</td>
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<td>VIQ</td>
<td>Verbal Intelligence Quotient</td>
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<td>WAIS</td>
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Chapter I

Introduction

Cognition is the internal structures and processes that are involved in the acquisition and use of knowledge, including sensation, perception, attention, learning, memory, language, thinking and reasoning. Cognitive processes are not localized to discrete portion of the brain but are a direct result of interactions among anatomically connected brain areas (Purves et al., 2007).

Cognitive impairment can include a progressive deterioration of intellectual ability (e.g., dementia), impairment of memory, aphasia, apraxia, one of the agnosias or changes in executive function (e.g., initiating, planning, and regulating task performance) (Cavanagh et al., 2002).

Cerebrovascular diseases are the second most common cause of cognitive decline and dementia. Stroke can have a massive effect on cognitive function, and dementia is a common outcome of stroke. Cognitive impairment in stroke patients has a prevalence of 17-38%. Cognitive impairment is associated with many short and long term poorer outcomes including poorer functional recovery and has a significant confounding factor to physical rehabilitation (Saxena, 2006).

The mini mental state examination (MMSE) is a brief, quantitative measure of cognitive status in adults. MMSE can be used to screen cognitive impairment, to estimate the severity of cognitive impairment at a given time, to follow the course of cognitive changes in an individual over time and to document an individual’s response to treatment (Folstein et al., 1975). The MMSE has been shown to be sensitive to the effects of a variety of neurological disorders including cerebrovascular disease, and it can be used to predict and track cognitive function in longitudinal studies and clinical trials (Dunitz, 2002).

RehaCom is a comprehensive and sophisticated system of procedures for computer-assisted cognitive assessment and rehabilitation. This practical tool assists the physical therapists in the assessment and rehabilitation of cognitive disorders that affect attention concentration, figural memory, reaction behavior and logical reasoning. Developed from the ground-up as an assessment and therapy tool - not a computer game - RehaCom can be used in the assessment and therapy of cognitive disorders (www.hasomed.de, 2008).
Barthel index (BI) measure a person's daily function specifically the activities of daily living and mobility. The assessment can be used to determine a baseline level of functioning and can be used to monitor improvement in activities of daily living over time. The scores for each of the items are summed to create a total score. The higher the score, the more independent the person is (Van Der Putten et al., 1999).

1.1. Statement of the problem:

Does cognitive impairment have an impact on functional abilities of stroke patients?

1.2. Purpose of the study:

The purpose of this study is to investigate the impact of cognitive impairment on functional abilities of stroke patients.

1.3. Significance of the study:

One third of surviving patients of stroke present with persistent cognitive impairment that has subsequent impact upon quality of life. Cognitive impairment can slow rehabilitation and increase the admission period in hospital. Long-term effects of cognitive impairment are as or more significant than physical impairments in re-establishing family and social activities (Cavanagh et al., 2002). Some aspects of neuropsychological functioning (e.g., presence of neglect, aphasia, anosognosis, verbal memory and attention deficits) show promise as a mean of predicting post stroke functional outcomes. This suggests that these areas of neuropsychological functioning may be targeted for rehabilitative efforts (Barker-Collo and Feigin, 2006).

There are various researches that studied the relationship between cognition and functional abilities in stroke (Tatemichi et al, 1994; Pedersen et al, 1996; Kathleen et al, 1998; Mokashi, 2005). In the current study using new objective equipment as RehaCom in combination with traditional screening tool as (MMSE) help to raise more accurate scores considering the level of cognitive abilities. The importance of the current study for physical therapy arise from the fact that the effect of cognition on functional activities plays a fundamental role in rehabilitation program and can manipulate the whole plane of treatment.
1.4. Delimitations:

This study was delimited to the following:

- Thirty stroke patients due to cerebrovascular accident (CVA) in the domain of the carotid system divided to fifteen patients with right CVA and other fifteen patients with left CVA were selected from the department of neurology, Faculty of Medicine, Cairo University and from the outpatient clinic in the Faculty of Physical Therapy, Cairo University.
- The patients’ ages ranged from 45-60 years.
- Duration of illness ranged from three to 18 months.
- The patients were medically stable with mild degree of spasticity (grade 1 and 1+ according to modified Ashworth scale).

1.5. Limitations:

This study was limited by the following factors:

- Small sample size.
- Small number of females compared to males in the studied group.
- Choosing the sample of educated patients without selecting a specific level of education.

1.6. Basic assumption:

It was assumed that:

- The patient's motivation and cooperation were the same for every patient.
- The calibration of the equipment used in this study was precise and insured to minimize any source of error.

1.7. Hypothesis:

It is hypothesized that there is no impact of cognitive impairment on functional abilities of stroke patients.
Definition of Terms

1. Attention Concentration:

The cognitive process of selectively concentrating on one aspect of the environment while ignoring other things. Attention has also been referred to as the allocation of processing resources.

2. Figural memory:

The ability to store, retain, and recall information related to figures.

3. Index stroke:

The acute onset of a focal neurological deficit attributable to vascular disease of the brain that lasted >24 hours and was supported by CT scan (normal or relevant infarct) performed within 1 week of symptom onset (Moroney et al., 1998).

4. Logical reasoning:

Three kinds of logical reasoning can be distinguished: deduction, induction and abduction. Given a precondition, a conclusion, and a rule that the precondition implies the conclusion, they can be explained in the following way:

- Deduction means determining the conclusion. It is using the rule and its precondition to make a conclusion. Example: "When it rains, the grass gets wet. It rains. Therefore, the grass is wet." Mathematicians are commonly associated with this style of reasoning.

- Induction means determining the rule. It is learning the rule after numerous examples of the conclusion following the precondition. Example: "The grass has been wet every time it has rained. Therefore, when it rains, the grass gets wet." Scientists are commonly associated with this style of reasoning.

- Abduction means determining the precondition. It is using the conclusion and the rule to support that the precondition could explain the conclusion. Example: "When it rains, the grass gets wet. The grass is wet, therefore, it may have rained." Diagnosticians and detectives are commonly associated with this style of reasoning.
5. Psychometrics:

The field of study concerned with the theory and technique of educational and psychological measurement, which includes the measurement of knowledge, abilities, attitudes, and personality traits. The field is primarily concerned with the construction and validation of measurement instruments, such as questionnaires, tests, and personality assessments.

6. Reaction behavior:

The human response to external stimulation.

7. Reaction time:

The elapsed time between the presentation of a sensory stimulus and the subsequent behavioral response.

8. Quartile reaction time 1:

The shortest time was taken by the subject to solve the task of logical reasoning (in milliseconds).

9. Quartile Reaction time 3:

The longest time was taken by the subject to solve the task of logical reasoning (in milliseconds).
Chapter II

Review of Literature

In this chapter the following headings will be reviewed:

2.2. Assessment of cognition.
2.3. Stroke and its complications.
2.4. Cognitive impairment after stroke.
2.5. Neuropsychological outcomes of stroke.
2.6. Predicting functional stroke outcome from neuropsychological data.
2.7. Cognition and motor control.
2.8. Activities of daily living.
2.9. Impact of cognitive impairment on functional abilities.

2.1. Cognition:

Cognition refers to the integrated functions of the human mind that together result in thought and goal-directed action. Simply, cognition involves the acquisition, processing and application of information in daily life. Cognition is at the core of an individual’s essence or personhood. Cognition not only influences what person chooses to do, but also it dictates how an experience is remembered and interpreted (Radomski & Latham, 2007).

Human cognition can be referred as a system, which means that it’s a set or assemblage of things, connected, associated or interdependent, so as to form a complex unity. Like all systems, the cognitive system can be split into a series of highly connected, but nevertheless potentially separable subsystems. These are the major components or parts of the cognitive system, and correspond to the major sets of operations that the human mind performs. These subsystems are the main elements of cognition including memory, vision, language, attention and skills. During examining the elements of cognition, the dynamic and changing nature of these elements especially memory, perception and skills should be considered. (Hampson & Morris, 1996)
Memory is the quintessential changing system in that, like a good library, new materials is continually entering and being classified. However, unlike a library, it seems that retrieving materials from memory, the act of remembering itself, can some time result in changing to stored information. Memory is always in a process of flux; we cannot hold it still nor stop it from altering. Perception is constantly changing too. The more we see, the more we learn to see. Human skills develop and improve with time; they are rarely static. (Hampson & Morris, 1996).

2.1.1. Memory:

Memory, which is one of the central elements of cognition broadly refers to information storage and retrieval. There are many conceptions of the way this processes occurs (Baddeley, 1990; Lezak, 1995). Figure (1) shows Atkinson and Shiffrin’s information-processing model of memory (1971) which highlights stages of acquisition and employing new knowledge and skills.

![Diagram of information-processing model of memory](image)

**Figure (1):** The diagram of information-processing model of memory (Atkinson and Shiffrin’s, 1971)

The information-processing memory is explained as following:

- **Sensory registers:** information from the environment is briefly (milliseconds) held in registers or stores specific to the human senses (Lezak, 1995). This registration stage has been called the intake valve for determining what data from the environment are ultimately stored. This phase is influenced by acuity of the senses (such as hearing and vision), affective set and perception (Radomski & Latham, 2007).
• **Short term memory**: the short term phase of the information processing has many labels: immediate memory, short term memory and working memory. The term "working memory" connotes the effortful deployment of cognitive resources during this stage. In short, for input from sensory registers to proceed to storage in long term memory, it must be the subject of deliberate concentration in working memory for approximately 30 seconds. Without this focused attention, the memory trace decays and the memory is not retained (Lezak, 1995).

Unlike long term memory, which is thought to have an infinite capacity, working memory has a restricted holding capacity of seven plus or minus two chunks of information (Miller, 1956). In addition to its role in information processing, working memory is the seat of conscious thought used in concentration and problem solving. Based on electrochemical activity in the brain, working memory reflects the contribution of attention to the memory process (Radomski & Latham, 2007).

• **Long term memory**: whereas data in working memory has a short shelf life, information in long term memory can be stored for a lifetime (Glover et al, 1990). When someone remembers information (an event that occurred an hour ago or a year ago), data are located and retrieved from long term memory and are held for conscious attention and thought in limited-capacity working memory. Storage in long term memory is based on relatively permanent changes in brain cell structure, although there does not appear to be a single local storage sit for stored memory (Lezak, 1995).

Long term memory is thought to consist of two subsystems, declarative memory and procedural memory. Declarative memory holds factual information, which is subdivided into episodic memory (knowledge of personal information and events) and semantic memory (knowledge of facts about the world). Procedural memory holds information related to knowing how to do things. It allows us to learn and perform skilled motor actions (Eysenk & Keane, 1990).

2.1.2. Vision:

Human perceives by seeing, hearing, touching, tasting and smelling. Vision is one of the major perceptual systems through which people learn about the world around them. Vision is clearly a vital system that plays a great role in cognitive function. Human cognition is a unique
blend of powerful memory systems, highly developed pattern recognition abilities and general purpose skills to interact with changing environment. All of these elements of cognition are important in the case of vision. Vision involves more than pattern of recognition, it draws on memory & drives and is informed by action (Hampson & Morris, 1996).

2.1.3. Language:

Language is central to human activity. Once language has been acquired, it is used almost continuously. People talk to other people, write to them and when not talking, writing, listening or reading, much of the remaining time is spent in thinking in which an inner voice using familiar words is normally experienced. As language is studied, more of its complexities become more apparent (Hampson & Morris, 1996).

Language is composed of semantics, syntax and pragmatics. The study of semantics is the study of the meaning of the words both by themselves and when put together to form sentences and long statement. Language is essentially a mean of communication and it’s successful only if meaning is communicated by the person uttering a statement to the person who hears or reads this statement. The study of meaning and its communication is therefore central to the study of language (Hampson & Morris, 1996).

A traditional model of verbal communication has been called the code model. In this model, thoughts are translated by some linguistic encoding device into words which can be transmitted either vocally or in writing. These messages are then received by the hearer and decoded via a linguistic decoding device into the appropriate thought and intended meaning, such a code model is inadequate to describe fully and properly the nature of language communication. It does, however, form a useful starting point for identifying some of the steps involved in language communication (Lezak, 1995).

The study of syntax is the study of the appropriate and inappropriate ordering of words in any particular language. It is rare for anyone to utter single words at time. Normally, humans speak in single sentences. For communication to be possible it’s necessary for the words to be put together to satisfy the rules of the particular language being spoken. The third domain of the study of language to be considered here is pragmatic. The study of pragmatic investigates why, in a given situation, a particular utterance is chosen. Why, for example, do people say "lovely weather" on a rainy day and how do other people understand that this is an ironic comment on
the weather rather than a crazy and false statement? The pragmatic aspects of language and the influence of the particular situation the speaker and the listener are in have become important issue in the study of language (Hampson & Morris, 1996).

The code model of verbal communication assumes that thought is the currency of the cognitive system and that language is used merely as a code for communication to another person. Thoughts are translated into words so that they can be transmitted to the other individual (Hampson & Morris, 1996).

2.1.4. Attention:

Attention is the deployment of mental resources for concentration. Each person is thought to have a limited capacity for consciously attending to information a hard-wired upper limit that dictates how many inputs can be simultaneously processed (Radomski & Latham, 2007).

According to Sohlberg & Mateers (2001), there are four levels of attention:

(1) Sustained attention, which is the capacity to maintain attentional performance over time.

(2) Selective attention, which occurs when an individual concentrates on one set of stimuli while ignoring competing stimuli.

(3) Divided attention, which allows a person to respond to more than one task at a time and is a more complex mental skill than sustained and selective attention.

(4) Alternating attention, which is necessary when one flexibly shifts attention between multiple operations.

2.1.5. Skill:

Skill is a very important element of cognition. When talking about skill sensory-motor and cognitive skills are usually considered. Car driving is an example of a sensory-motor skill in that what is involved is the use of sensory information in the selection and modification of the movements that person makes. Crossword solution is a cognitive skill that is not dependent upon learning how to use sensory input to continuously modify movement. Instead, it is dependent on how to carry out a cognitive task. The distinction is important since not all conclusions that may be reached about one type of skill will necessarily apply to the other. Nevertheless, there seem to be many similarities in the processes that underlie both types of skill acquisition (Lezak, 1995).
For many skills it's easy to explain what must be done at a gross level, the problem is in performance. To ride a bicycle, all that one have to do is to sit on the saddle, push around the pedals with feet and turn the front wheel with the handlebars to steer, it's simple, but perhaps not when person try it for the first time. Riding a bicycle actually depends on knowing how to do many things that are easy to take for granted: knowing how to balance, knowing how to compensate for turns in the wheel when steering or when looking behind for traffic, knowing how much effort to put into each foot while turning the pedals. The example of riding a bicycle illustrates the difference between declarative (or propositional) and procedural knowledge. (Hampson & Morris, 1996).

Declarative knowledge is knowing facts and knowing that something is the case. Procedural knowledge is knowing how to do something perhaps with no conscious ability to describe how it’s done. Describing to someone what riding a bicycle entails, in declarative terms, is not sufficient for them to acquire the procedural knowledge needed to ride one. On the other hand, processing procedural knowledge of how to ride bicycle does not equip anyone with declarative knowledge. Most of subjects who can ride bicycle will not possess the declarative knowledge. The skill acquisition is the study of the acquiring of the procedural knowledge. One of the problems facing driving instructors and sports coaches is the difficulty of translating what is often a simple amount of declarative knowledge into procedures that the trainees can actually carry out. Their main tool is practice, but practice with as much guidance as possible. (Hampson & Morris, 1996).

Although the major elements and subsystems of cognition mentioned above are examined separately, these elements work smoothly together for the benefits of the system as a whole. Without perception, no new information could enter memory; without memory, things seen could not be interpreted in term of familiar categories. Similarly, language might sharpen material in memory and perhaps alter how we perceive things, but without memory and perception, the ability to use language would never develop in the first place (Radomski & Latham, 2007).

If only three aspects of human cognition had to be chosen, they would be: first, its powerful memory subsystems which support virtually all cognitive abilities from perceiving to thinking; second, its remarkable pattern recognition abilities which arise not just in perception,
but are used in memory, language, thinking, problem solving and skills; third, its flexible ability to interact and communicate with a changing world. Memory pattern recognition and (perceptual-motor, cognitive and communicative) skills lie in the core of cognition (Radomski & Latham, 2007).

Using cognition is heavily dependent on the elements of cognition. The term "using cognition", in which the emphasis changes from studying the cognitive system to what can be done with it, the mind and elements of cognition can be used for remembering, planning & acting, reading, problem solving and decision making. The number of possible applications of the human mind is of course potentially infinite, but to look at each task that the mind can do is often less interesting than using a range of related tasks to draw conclusions about its general operating characteristics or the sorts of typical jobs we can do with the cognitive system (Hampson & Morris, 1996).

Cognition clearly influences the selection, performance, analysis and learning of everyday activities. In addition to its central role in occupational functioning, a person’s cognitive function influences the acquisition of new activities of daily living (ADL) (Radomski & Latham, 2007). Sandstrom & Mokler (1999) described cognitive function as a key outcome variable for persons with severe motor stroke. Hanks et al., (1999) found that cognition predicted functional abilities and social integration six months after discharge from acute rehabilitation. To identify and remove barriers that interfere with occupational functioning and to anticipate rehabilitation outcomes, occupational therapists should examine patients’ cognitive function as a part of comprehensive occupational therapy assessment.

2.2. Assessment of cognitive functions:

Cognitive state examination can be crucial for producing evidence of an organic component in a mental illness. The number of tests and procedure available for processing cognitive function is rather be wildering and it’s therefore helpful to acquire a standard routine. This also has a value in building up the clinician’s experience of the different tests and the meaning to be put on failure in various situations (Lishman, 1998).

Most of the brief short hand cognitive tests employed by the psychiatrist lack adequate standardization and validation. Indeed when their value has been tested the tests have often,
taken individually, proved to be remarkably inefficient in distinguishing between organic and functional psychiatric illness. It is proved to be closely related to educational level and general intelligence, some are markedly affected by increasing age and other by emotional disturbance. Some of the more detailed psychometric procedures elaborated by psychologists are clearly superior for the task of identifying organic psychiatric disorder, but are too cumbersome for use in every patient (Lishman, 1998).

Nevertheless the routine tests available to the clinician have a definite value for their own. These tests have the important virtue of throwing a very wide net and touching upon a number of facets of cognitive function in a reasonably concise manner. In the course of administrating them, the examiner also picks up numerous indirect clues (e.g.: the patient behavior during attempts at the tests and the nature of the approach) which provide important information in themselves (Lishman, 1998).

Cognitive function should be assessed systematically (Chow & Maclean, 2001 and Registered Nurse Association of Ontario [RNAO], 2003). Without systematic assessment, the pathological conditions go unchecked and the individuals with these conditions face much greater accelerated and long term cognitive and functional decline and death (Fick & Foreman, 2000; Fick et al., 2002; Hopkins & Jackson, 2006 and Lang et al., 2006).

It is clear that the assessment of cognitive function is the first and most crucial step in a cascade of strategies to prevent, reverse, halt or minimize cognitive decline (Cummings et al., 1994 and Delis et al., 2000). Since clinicians need to measure the cognitive performance of patients, a very large body of tests has accumulated over the past to self questionnaires for the carer (Chow & Maclean, 2001 and RNAO, 2003).

The cognitive function test should be reproducible, valid in practice and readily comprehensible and the best battery should encompass a set of modules of tests assessing specifically different cognitive domains that one can use or combine to meet the patient/research protocol`s specific needs (Cappa et al., 2008).

Cappa et al., 2008 mentioned that psychometric cognitive function tests can be classified in different ways, for example:
* Cognitive (e.g.: stroop test; stroop, 1935), behavioral (Lebert et al., 1998) and quality of life (Naglie et al., 2006) tests and questionnaires.

* Global (e.g.: Mini Mental State Examination; Folstien et al., 1975), multidomain tests sensitive to different cognitive processes (categorical fluency involving both executive functions, working memory and semantic memory) or domain-specific tests (e.g.: Gruber and Buschke memory tests; Gruber et al., 1988).

* A psychometric approach in which the performance of the subject is compared to validated norm (e.g.: IQ measurement with WAIS; Wechsler, 1997) versus concept-driven cognitive evaluation (dissociated performance for producing proper names compared to common names).

Many neuropsychological assessment batteries were developed but Wechsler Adult Intelligence Scale-Revised (WAIS-R) is the most popular and commonly used tests. Wechsler defined intelligence as "the global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment". WAIS-R is a general test of intelligence. It consists of 11 subtests divided into two parts, verbal and performance, it takes 60-90 mins to administer and is used at patients aged between 16 - 74 years old (Franzen, 2000).

WAIS-R consists of six verbal subtests and five performance subtests. The verbal tests are: Information, Comprehension, Arithmetic, Digit Span, Similarities, and Vocabulary. The performance subtests are: Picture Arrangement, Picture Completion, Block Design, Object Assembly and Digit Symbol. The scores derived from this test are a Verbal IQ (VIQ), a Performance IQ (PIQ) and a Full Scale IQ (FSIQ). Test-retest reliability coefficients affirm the excellent reliability of the Verbal and Full Scales, and show Performance IQ to be quite acceptable (0.89 to 0.90). Test-retest coefficients for the subtests confirm the reliability of all tasks except Object Assembly and Picture Arrangement. Wechsler Adult intelligence scale III [WAIS-III] is the third edition of the original WAIS which along with reorganization of subtests and updated normative data, has expanded the age range to 89 years old (Franzen, 2000).

The Neuropsychological Assessment Batteries [NAB] is a comprehensive, integrated, modular battery of 33 new neuropsychological tests developed to assess a wide array of neuropsychological skills and functions in patients (ages 18-97 years) who have known or suspected disorders of the central nervous system. The individual tests are grouped into six modules: Attention, Language, Memory, Spatial, Executive Functions and Screening (which
allows the clinician to determine which of the other five domain-specific modules are appropriate to administer to an individual patient. The NAB have excellent psychometric properties: (a) include extensive normative and validation data, (b) provide clinical information that meet the needs of a broad range of modern referral sources, (c) offer two equivalent forms that reduce practice effects and facilitate reevaluation. The examiner can administer the entire NAB for a comprehensive evaluation of neuropsychological functioning in less than four hours (Stern & White, 2003).

Many dementia batteries have been developed. The Mini Mental State Examination (MMSE) is one of these batteries. It was developed as brief tool for grading the level of cognitive impairment in the elderly as well as in screening for dementia. It's a 30 point scale, consisting of several orientation questions (ten points), a registration and recall task (six points), an attention task (five points), a multistep command (three points), two naming tasks (two points), a repetition task (one point), a reading comprehension task (one point), a written sentence (one point) and a visual construction task (one point). The reading comprehension task involves the patient reading a sentence and performing the command. The construction task involves copying interlocking pentagons. These items are generally printed on the form used to facilitate administration of the test. This test is rapid to administer (10 mins) and it is strongly influenced by age and education (Herndon, 2006).

The Addenbrookes's Cognitive Examination [ACE] (Appendix 5 and 14) is essentially an elaboration of MMSE that was designed to be more sensitive to amnestic syndromes and to isolated frontal or linguistic deficits than most mental status examination, yet it's not as complex as Mattis dementia rating scale. It takes about 15-20 mins to administer (Lezak et al., 2004).

The ACE consists of six sections; Orientation (ten items from MMSE); attention/mental tracking (eight points: repetition of three words and five serial seven subtraction); episodic and semantic memory (35 points; recall of three words after distraction, learning of a seven-element name and address over three trials, recall of the address and name after five min. delay and giving the name of four government figures); verbal fluency (up to seven points each for phonemic[“P” words] and semantic [animals] fluency); language (28 points: naming items depicted in 12 lines drawing; comprehension of three simple commands [two spoken and one written], two complex commands, and a three steps command; repeating three words & two
phrases; reading two five-item lists composed of either regular and irregular words [each scored all or non]; and writing a sentence); and visuospatial ability (five points: copying intersecting pentagons, copying a cube and drawing a clock face with numbers and hands set to ten past five) (Lezak et al., 2004).

Single domain tests are frequently used. These tests include memory, attention, perception, language, construction, reasoning and executive function. The stroop test is one of the most commonly used diagnostic tools when determining an attention problem. It involves focusing on one particular feature of a task, while blocking out other features. It includes three phases: (1) read words of colors printed in black, (2) name the color of colored patches, (3) name the color of the ink of works designating colors (where the meaning of the words & color of ink are different) (Lezak et al., 2004).

Formal neuropsychological testing, which usually includes tests of multiple cognitive domains, is the best approach to evaluate mildly impaired patients when a diagnosis is in question. Psychometric tests with well-defined properties may offer the best way of documenting progression in cognitive impairment, although the briefer instruments have been used for the same purpose. Development and validation of neuropsychological batteries that can be used in longitudinal studies will be important for future clinical trials. Psychometric batteries that minimize ceiling effect are necessary for patients with mild cognitive impairment. A disadvantage of many instruments used to assess cognition is that severely impaired subjects may not be able to perform the test (Herndon, 2006).

2.2.1. Mini Mental State Examination (MMSE):

Among all these instruments assessing cognitive function, Mini Mental State Examination (MMSE) that was developed by Folstein et al., (1975) is the most frequently recommended instrument and the most widely used. MMSE has been the most commonly used screening instrument for cognitive functioning for more than twenty five years because it’s brief. It consists of eleven items and takes about 7 to 10 minutes to complete and it’s easy to use. MMSE is composed of items assessing orientation, attention, memory, concentration, language and constructional abilities (Capezuti et al., 2007).
Although MMSE is designed to produce a global score for rating cognitive status, it contains some tasks which could be classified as "domain it specific". It is within the capabilities of older adults, and yields a single summary score that can be used as the primary cognitive outcome measure for a clinical trial (Guiloff, 2001).

Despite MMSE considered the best available method for screening of cognitive impairment, Tombaugh & McIntyre (1992) stated that MMSE is significantly influenced by education (individuals with less than eighth grade education commit more errors), language (individuals for whom English is not their primary language commit more errors), verbal ability (MMSE can only be used with individuals who can respond verbally to questioning) and age (older people do less well). Borson et al., (2005) contended that despite these limitations, it remains the most frequently recommended and most commonly used tool to assess cognitive functioning. Herndon, 2006 insured that MMSE makes an excellent choice for office use. By keeping its limitations in mind, clinicians can use it to advantage of assessing cognitive status.

Test-retest reliability of MMSE has been examined in many studies and the results of test-retest reliability ranged from 0.80-0.92 (Anthony et al., 1982; Dick et al., 1984; Thal et al., 1986; Fillenbaum et al., 1987 and Uhlmann et al., 1987). Inter-rater reliability has also been widely studied. Molloy et al., 1991 reported inter-rater reliability of 0.69 and 0.78. In a sample of 15 neurological inpatients, inter-rater reliability gave a Pearson correlation of 0.95 and a Kendall coefficient of 0.63.

Although factor analyses have used different types of sample and differing versions of the MMSE, they commonly identify factors relating to orientation, memory and attention (Folstien et al. 1975). In terms of content validity, the MMSE measures eight of the 11 main aspects of cognitive status; it omits abstraction, judgment and appearance (Foreman, 1987).

2.2.2. RehaCom:

RehaCom is a comprehensive and sophisticated system of procedures for computer-assisted cognitive assessment and rehabilitation. This practical tool helps the therapist in the assessment and rehabilitation of cognitive disorders that affect attention concentration, figural memory, reaction behavior and logical reasoning. This system developed from the ground-up as
RehaCom is a very comprehensive tool to assist with assessment and therapy for Cognitive disorders. It will make life easier but will never be a substitute for a competent clinician (www.anatomicaconcept.com, 2008).

The patient or the subject can work with RehaCom on a regular computer (executable with Windows NT4/98/ME/2000/XP). The system makes scientifically funded tasks available to the patient over the screen and loudspeakers. These tasks are solved by the patient in the sense of an assessment of cognitive functions. The operation of RehaCom is easy to learn for the affected person. Motor or seriously cognitively handicapped people can use the RehaCom board - a special keyboard with simple, large and clear keys. Alternatively, a usual computer keyboard can be used. Also for the therapist handling RehaCom is very fast and easy to learn. In all procedures the operation interface is identical (www.hasomed.de, 2008).

2.3. Stroke and its complications:

Cerebrovascular accident (CVA) or "stroke" is the third leading cause of death and the major cause of adult disability. Stroke is often a sudden and devastating event causing changes in the patient's lifestyle and exerting major psychological and economic stress on the person and the family member (Turner et al., 2002).

Stroke may be classified into two general types; ischemic and hemorrhagic. Ischemia refers to disruption of the blood supply to an area of the brain, which eliminates its supply of glucose and oxygen resulting in an infarct or area of dead tissue. Infarction may occur as a result of thrombosis, where a plug forms blocking of blood flow. About 50% of stroke is caused by
cerebral thrombosis, which falls into two subcategories: large-vessel thrombosis and small-vessel thrombosis. Blood flow may be blocked by an embolism, where a plug of thrombic material travels through arteries as they branch off into smaller vessels and eventually lodges in a blood vessel that is too small for it to pass through. Approximately, 30% of stroke is caused by cerebral embolism. Lacunae are defined by the size of the area affected rather than by etiology (Mohr et al., 1978).

Hemorrhagic stroke, which accounts for approximately 20% of all strokes, may be due to intracerebral hemorrhage or subarachnoid hemorrhage. An intracerebral hemorrhage (also called a parenchymal hemorrhage) occurs when a diseased artery within the brain ruptures, flooding the surrounding brain tissue with blood. Most signs and symptoms associated with intracerebral hemorrhage are caused by the compression of brain structures and blood vessels. Subarachnoid hemorrhage (bleeding into the skull or cranium that occurs when a blood vessel on the surface of the brain ruptures and bleeds into the meninges) usually follows the rupture of an aneurysm or an arteriovenous malformation (Mohr et al., 1978).

The impairment associated with CVA can be motor, perceptual, sensory, cognitive and psychological. This impairment can have an impact on the individuals’ daily occupation. Deficits in concentration, memory, decision making and sequencing, for example; will have a direct bearing on the individual's ability to respond to treatment and retain new information. Difficulty with speech or comprehension can cause the person to feel isolated and lacking of self worth and to appear uncooperative to treatment. It's therefore important to identify cognitive deficits in order to discriminate it from perceptual or speech impairments (Turner et al., 2002).

For prediction of physical recovery following stroke, the type, lesion size and stroke severity have been examined, and the focus was on survival as an indicator of positive outcome. Wide variation exists in the reported survival rates for patients with stroke and its subtypes. Generally the findings indicate that those with ischemic stroke (especially lacunar) have relatively high short and long-term survival rates, while survival after hemorrhagic stroke is less likely (Barker-Collo & Feigin, 2006).

In addition to the subtype, a number of stroke-related and demographic factors appear to influence outcome; as well as; the relationship between neuropsychological functioning and outcome. Positive functional outcomes from stroke have been significantly related to absence of
prior stroke, less severe initial neurological deficit, stroke involving cortical structures and left hemispheric lesions (Macciacchi et al., 1998). Thus, an individual with right hemisphere lesions, with multiple focal lesions, with history of previous stroke or with severe initial neurological deficits would be expected to have a poorer outcome following stroke (Barker-Collo & Feigin, 2006).

Loss of consciousness has also been linked to stroke outcome. Ebrahim and Harwood (1999) stated that “impaired consciousness has stood the test of time as an adverse prognostic sign for survival”, a conclusion that agreed with Bonita and Beaglehole (1988) and Anderson et al., (1994).

In addition, younger age has been correlated with better recovery from stroke (Kalra, 1994; Giaquinto et al., 1999; Jehkonen et al., 2000). Ween et al., (1996) found that patients under age of 55 at stroke onset returned home more often than older patients. They noted that age is a reliable predictor of outcome mainly in young and very old stroke patients.

Low education was found to be inversely correlated with making improvements in a rehabilitation program (Lehmann et al., 1975). In a study done by Nyrkkoe, (1999) the influence of education and age on the outcome of 115 stroke patients was examined. He found that patients with higher education had better compensation abilities, and that younger patients with more reserve capacity had more potential to be improved. However, education played no significant role regarding outcome after stroke in another study done by. Nonetheless, Turner et al., 2002 stated that a young and well-educated patient having a single stroke is expected to have a more positive outcome than recurrent small vessel disease in an older, less educated individual.

The disablement resulting from stroke is frequently an admixture of physical and mental problems. The latter may be attributable directly to the sustained brain damage, or largely represent the individual’s reaction to the handicaps imposed upon him. In either event his personality make-up and his life situation can have a profound effect on overall adjustment to the disability, and the mental components of the picture will often be decisive in determining the level of success achieved in rehabilitation. It's therefore unfortunate that little attention has been directed to cognitive and psychiatric problems of stroke and to the ways in which these problems interact with the physical disabilities (Lishman, 1998).
2.4. Cognitive impairment after stroke:

Defects in the intellect or other higher cortical function are among the more serious sequelae of stroke. These defects cause delaying and often gravely compromising attempts at rehabilitation. Such elements in the clinical picture may be less immediately obvious than hemiplegia or other physical handicap, yet often prove to be the factors which are truly responsible for failure to regain independence. Thus among patients who become long-stay invalids, permanently confined to chair or bed, paralysis by itself rather seldom accounts for their incapacity and may even contribute little towards it (Lishman, 1998).

Mental impairment that may follow a single stroke usually proves to be focal in nature once the initial clouding of consciousness has cleared. For some time, however, global confusion and disorientation may be much in evidence, and can be slow to clear when the cerebral damage has been extensive. It may be aggravated by anoxia from congestive cardiac failure or respiratory infection, or be attributable in part to the patient's difficulty in coping with new found barriers to communication with his environment. As the situation improves the true extent of cognitive dysfunction is revealed. The longer the clouding consciousness has persisted the more likely that residual mental deficits are severe and extensive (Lishman, 1998).

Considerable difficulty may be encountered in assessing the extent of global intellectual impairment, particularly if the patient is dysphasic or with marked constructional difficulties. Agitation, depression or apathy in the early stages of stroke may give a false impression of cognitive impairment. A circumscribed amnesia syndrome due to posterior cerebral infarction may be wrongly attributed to cognitive impairment in such patients (Lishman, 1998).

In a review of 45 hemiplegic patients, Adams & Hurwitz (1963) showed that physical disability, such as dense paralysis or limited exercise tolerance, accounted for failure to respond to treatment in less than half of them. In 40% of patients, severe residual paralysis and sensory defects were accompanied by varying degrees of generalized intellectual impairment and a correspondingly high rate of incontinence. Failure to respond to treatment seemed to derive from impaired comprehension, difficulties in communication, inattentiveness and lack of spontaneous effort. Those patients were frustrated by preservation and couldn’t assimilate or retain instructions. Most of these infarctions had occurred in the distribution of the middle cerebral artery of the dominant hemisphere. Ten further patients showed neglect of the affected limbs or
even denied that they were in any way abnormal. Some disowned their hemiplegic limbs or complained of bizarre changes within them. The latter had at first given a superficial impression of alert and responsible behavior, which was later belied by defective grasp, inattentive lapses and persistent incontinence. Seven were mainly in capacitated by postural imbalance which had often led to profound loss of confidence. Other patients showed severe receptive dysphasia, apraxia of gait or emotional disturbance with catastrophic reactions.

Disturbances of language accompany two-thirds of patients with left hemispheric lesions, may be even without paralysis. They contribute alarm addict handicap and source of frustration, frequently outlasting recovery of motor function. Patient with expressive loss but good comprehension will in general make much better adjustment than when understanding is faulty. Apraxic disturbance may persist as a barrier to rehabilitation when motor paralysis has cleared, particularly an apraxia of gait. Thus patients with dominant hemisphere infarction appear to make a quick recovery from hemiparesis, but fail to regain a normal pattern of walking and postural control (Adams, 1967).

Disturbed awareness of the self or space commonly occurs after right hemisphere lesions than left. Neglect of the left half of external space may be accompanied by left sensory inattention, neglect or unawareness of body parts, or frank denial of disability (Lishman, 1998). Occasionally, however, exceptions are found and such symptoms result from left hemisphere lesions leading to a complex admixture of deficits: for example, Welman (1969) reported a right handed man who had a left parietotemporal infarction, suffered from right hemiplegia, aphasia for some hours, apraxia, hemisomatognosia, and anosognosia for the right side of the body, left unilateral spatial agnosia, visual constructive apraxia, left-right disorientation, loss of memory and finger agnosia in both hands.

The more florid aspect of anosognosia, involving verbal denial or disowning of paralysed limbs, usually subsides over several weeks, but neglect and inattention may endure. After severe infarction in the non-dominant hemisphere a characteristic pattern may emerge, providing immense difficulties for effective rehabilitation the patient has a dense hemianopia, hemiplegia and hemianesthesia but lacks insight into his predicament, may admit to nothing wrong with the left limbs or disown the arm. Sometimes this persists even after quite good recovery of power and the patient makes no constructive attempts to walk. Persistent incontinence is a common
accompaniment, adding to the poor prognosis for recovery of independence and social reliability (Adams, 1967).

Improvement over time in specific cognitive and perceptual disabilities may be expected to follow the course of decelerating curve. The percentage return of function gradually diminishing as time after stroke increases. In general most improvement can be expected within the first six months, but wide variation is seen. The influence of affective and motivational factors is often profound, delaying full recovery until several years have gone by. A considerable longer period must usually be allowed for the optimal resolution of dysphasia, visuospatial or topographical defects than of physical disabilities such as hemiplegia. The ultimate level achieved will depend crucially on the amount of brain tissue destroyed, the number of separate deficits involved and on the multitude of factors peculiar to the individual which dictate his adaptive capacity (Lishman, 1998).

The neglect and visuospatial function related to cognition can be seen either in the right or left strokes but it’s more severe in right than in left stroke Voos & Ribiero do Valle (2007). Sunderland et al., (1999) stated that visuospatial deficits were predictive of dexterity error rates for the right CVA and that the errors observed on the dexterity tasks suggested problems of visual attention or spatial judgment. There was no such association in the left CVA. They also stated that although these results are not completely clear cut, they are consistent with the proposal that visuospatial deficits were the major cause of dexterity errors after right but not left hemisphere damage. The results of Sunderland et al., (1999) agreed with many researches indicating reduction in the accuracy of rapid reaching for targets due to mild visual neglect or spatial disorientation after right hemisphere damage as the researches of Goodale et al., 1990 and Winstein & pohl, 1995.

Lezak & Loring, (2004) mentioned that spatial performance of right hemisphere damaged patients is adversely affected by lesions occurring anywhere in a fairly wide area while those patients with left hemisphere damage, with relatively severe damage to a well defined area, show impaired performance on spatial tasks. The author also hypothesized more diffuse representation of functions in the right hemisphere and more focal representation in the left. Moreover, lesions outside the right hemisphere’s sensorimotor area can contribute to motor deficits. But in the left hemisphere, motor deficits occur only with lesions involving the
sensorimotor area. Additionally, right hemisphere is more diffusely organized than the left which have been provided by the evidence that visuospatial and constructional disabilities of patients with right hemisphere damage do not significantly differ regardless of the extensiveness of damage.

Lezak & Loring, (2004) also showed the cognitive alterations with lateralized lesions when they stated that the most obvious cognitive defect associated with left hemisphere damage is aphasia and other left hemisphere disorders including: verbal memory or verbal fluency deficits, concrete thinking, specific impairments in reading or writing and impaired arithmetic ability. While for right hemisphere, perceptual deficits particularly left-sided inattention phenomena and those involving degraded stimuli or unusual presentations, are not uncommon. The visuospatial perceptual deficits that trouble many patients with right lateralized damage can affect different cognitive activities which show up as difficulty copying designs, making constructions and discriminating pattern of faces. Patient with right hemisphere damage may have particular problems with spatial orientation and visuospatial memory such that they get lost, even in familiar surroundings, and can be slow to learn their way around new area.

Walker et al., (2004) emphasized that Patients with right hemisphere damage had problems in selecting the correct sleeve, self-monitoring their left side or covering the paretic shoulder, suggesting deficits in visuospatial perception or neglect. Patients with left hemisphere damage dressed the non-paretic arm first or showed a disorganized dressing strategy, suggesting impaired action control due to apraxia. Moreover, Sunderland et al. (1999) reported that ideomotor apraxia gave rise to characteristic dexterity errors after left hemisphere damage whereas visuospatial deficits were predictive of the type of dexterity errors seen in right hemisphere damaged participants.

Godefroy & Bogousslauksy, (2007) emphasized that the most frequent deficit following right hemispheric strokes is hemi-spatial neglect where there is impaired or lost ability to react to or to process sensory stimuli in the hemispace opposite to the lesion side. They added that spatial neglect most frequently occurs following right hemisphere damage that involves parietal, temporo-parital, frontal, limbic and subcortical areas. Also they mentioned in particularly, at the cortical level, that these lesions include the angular and supramarginal gyri of the inferior parietal lobe, the temporo-parietal junction, the superior temporal gyrus and the inferior &
middle frontal gyri. While aphasia is considered the most important cognitive impairment that occurs following left hemisphere strokes.

Stein et al., (2009) stated that the neglect is a common and severely disabling neurobehavioral disorder that associated with isolated right hemisphere injury. He also emphasized that electrophysiological findings and functional brain imaging studies suggested that whereas the left hemisphere attends primarily to the right side or in a rightward direction, the right hemisphere can attend to both sides or in both directions.

2.5. Neuropsychological outcomes of stroke:

Important, but often neglected outcomes of stroke are neuropsychological sequelae, which occur in nearly half of stroke survivors (Dennis et al., 2000). In one study of neuropsychological functioning carried out on 229 Dutch individuals assessed two-month post-stroke, it was found that over 70% of these patients suffered impaired information processing and at least 40% suffered difficulties with memory, visuospatial and constructive skills, language and arithmetic (Hochstenbach et al., 1998).

Sachdev and colleagues (2004) examined a sample of 170 stroke and transient ischemic attack (TIA) survivors at three to six months post-stroke in comparison to 96 age matched controls. Those identified from thorough neuropsychological and medical assessment as having ‘vascular dementia’ (i.e., having progressive cognitive deficits across a number of areas of functioning of vascular origin) produced disturbed performances across all cognitive domains with verbal memory, especially retention, being less impaired. Those identified as having ‘vascular cognitive impairment’ (i.e., having specific, non-progressive areas of cognitive deficit of vascular origin) but not dementia had similar, but less severe disturbances. The most contributes used to differentiate impaired from unimpaired individuals were abstraction, mental flexibility, information processing speed and working memory. Magnetic Resonance Imaging (MRI) variables (e.g., volume and number of infarctions) did not help in discriminating between subject groups.

Stephens et al., (2004) examined cognitive impairments in 381 stroke patients without dementia who had been classified as ‘with and without vascular cognitive impairment (VCI)’
aged over 75 years. When compared to 66 age matched controls, stroke survivors were found to have significant deficits in attention and executive function, even those without VCI. Those with VCI were significantly more impaired on tests of expressive language, memory and executive function than those without VCI. In those identified as having post-stroke dementia, a similar profile emerged, but deficits were more pronounced, particularly in terms of memory and orientation. Another study of Nyenhuis et al., 2004 done on post-stroke cognitive impairment, but not on post-stroke dementia, reported similar findings of significant post stroke cognitive impairment across various areas of cognitive functioning.

While various aspects of neuropsychological deficits have been the focus of research in selected subgroups of stroke patients, there is a lack of population-based studies on neuropsychological impairment in stroke survivors, and neither a profile of long-term neuropsychological deficits nor its relationship with other long-term functional outcomes have been established (Barker-Collo & Feigin, 2006). In a population-based study in South London (Patel et al., 2002), it was found that cognitive impairment at four years after stroke was associated with greater likelihood of death during further follow-up and with greater disability (Barthel Index <15). However, in this study cognitive impairment was assessed by means of Mini-Mental State Examination (MMSE) only and the study suffered from a measurement bias. Similarly, outcome was assessed as overall level of functional independence, and thus is unable to speak to wider outcomes such as caregiver burden or health related quality of life.

Short-term (three months) cognitive impairment was evaluated in a small population-based study (n=99) in Melbourne, Australia (Srikanth et al., 2003). The study revealed that mild to moderate stroke severity was associated with a significant risk of cognitive impairment at three months after stroke.

If specific stroke subtypes are shown to have differing neuropsychological outcomes, then the need for community and rehabilitation services, educational and interventional programs in stroke patients and their families could also be different. However, data on the long-term outcomes in survivors of different stroke subtypes are scarce, limited to one-year follow-up, and often inconsistent (Sturm et al., 2002).
Few population-based studies have investigated neuropsychological outcomes of stroke subtype. In a study done in Melbourne by Sturm et al., (2002) and carried out on ischemic stroke patients examined after 12 months of insult, handicap (measured by the London Handicap Scale) differed significantly with severity of disability (measured by the Barthel Index). No information on hemorrhagic stroke subtypes was provided in this publication.

In the Australian study (Hackett & Anderson, 2000), incomplete recovery at one year after subarachnoid hemorrhage was found in 46% of survivors, of which ongoing memory problems were recorded in 50%, mood abnormalities in 39%, and speech problems in 14%, while a substantial proportion of survivors had diminished level of health-related quality of life.

In another comprehensive literature review of unruptured intracranial aneurysms (the most common cause of subarachnoid hemorrhage), Towgood et al., (2004) strongly suggested inclusion of comprehensive neuropsychological tests in the assessment of those who have suffered vascular accidents. Other studies also suggested that neuropsychological deficits following stroke are more important determinants of functional outcomes than physical disability (Lynch et al., 1997; Zhu et al., 1998; Kotila et al., 1999; Bays, 2001; Hochstenbach et al., 2001 and Patel et al., 2002).

The literature linking neuropsychological functioning to outcome after a neurological event has focused on prediction of specific outcomes in small samples and assessing only specific areas of neuropsychological functioning, such as memory, attention, language, visuospatial or executive functions (Barker-Collo & Feigin, 2006). Robertson et al., (1997) reported that sustained attention is predictive of functional status two years post-stroke. Goldstein et al., (2001) found that assessments of memory significantly predict instrumental daily living skills in the elderly.

This accumulating body of evidence strongly suggests that appropriate neuropsychological rehabilitation (including preventive rehabilitation) may improve functional outcomes and reduce burden of stroke. Yet, post-stroke rehabilitation has traditionally focused on physical and occupational therapy; as well as; speech & language training, and paid relatively little attention to neuropsychological screening and rehabilitation (Finlayson, 1990; Paolucci et al., 1996 and Dobkin, 2005).
If neuropsychological impairment were to be independently associated with long-term outcomes and costs of stroke, it would lead to a major shift in stroke rehabilitation strategies and corresponding health services change. However, before any changes in the stroke rehabilitation, strategies can be introduced with confidence; more information on the significance of long-term neuropsychological outcomes in various stroke types should be available on a community level (Dobkin, 2005).

Further works are needed to differentiate not only the direct effect of neuropsychological impairment on outcome, but also its indirect effects. For example, there is a need to determine the relationship between neuropsychological impairment and factors such as medication compliance, ability to participate fully in rehabilitation, provision of paid care and the impacts of these on outcome (Barker-Collo & Feigin, 2006).

Neuropsychologically speaking, the division of stroke subtypes in relation to etiology is not optimal. The purpose of neuropsychological assessment is to quantify the behavioral deficits associated with damage incurred to various brain areas and structures. In this context it would seem more relevant to introduce stroke groupings that are based upon which aspect of vascular distribution has been disrupted (e.g., middle cerebral artery distribution), which are likely to be more integrally related to the behaviors being quantified. In those studies that have approximated this approach, the most common mean of patients grouping has been based upon hemispheric affection (Barker-Collo & Feigin, 2006).

2.6. Predicting functional stroke outcome from neuropsychological data:

Identification of predictors of particular long-term outcomes in stroke survivors would allow identification of individuals who may benefit from specific rehabilitation services. This may improve planning of stroke care and rehabilitation services and would facilitate better information provision to individuals and their families with regard to an individual’s potential for recovery and the likelihood of surviving in the long term. Ideally, predictive models of stroke outcomes should be based on population-based studies in which various potential predictors of stroke outcomes are described and adjusted for adequately; and where standard diagnostic criteria and validated standardized measures of outcomes are used (Sackett et al., 1991).
Although prognostic factors of stroke outcomes have been the subject of much discussion in many literatures (e.g., Kalra et al., 1993; Fiorelli et al., 1995; Paolucci et al., 1996; Adams et al., 1999 and Petty et al., 2000), there have been only few studies that addressed some aspects of this issue in the population-based setting (Taub et al., 1994; Hackett et al., 2000 and Hankey et al., 2002), and even fewer for studies of hemorrhagic stroke (Hackett et al., 2000).

The literature linking neuropsychological functioning to outcome after a neurological event has to date focused on prediction of specific outcomes in small samples and assessing only specific areas of neuropsychological functioning, such as memory, attention, language, visuospatial and executive functions. Few studies had examined the contribution of neuropsychological tests for prediction of post-stroke outcome is reviewed in table 1 (Barker-Collo & Feigin, 2006).

Generally, the studies identified can be grouped into those that examined the relationship between general/screening measures of neuropsychological ability (e.g., Mini Mental Status Exam) and outcome; and those that examine the relationship of specific neuropsychological abilities tests/deficits and outcome (Ozdemir et al., 2001).

MMSE has been used extensively in post-stroke patients as a measure of general cognitive functioning. Scores of MMSE at admission have been found to predict motor impairment at discharge. MMSE scores have also been found to correlate highly with anosognosia (Wagner & Cushman, 1994), and anosognosia itself is predictive of poor prognosis for hemiplegia (Gialanella & Mattioli, 1992), mobility (Paolucci et al., 1996), and functional outcomes (Jehkonen et al., 2000).

It has been shown that specific areas of neuropsychological impairment are predictive of functioning and independence at discharge from acute stroke rehabilitation (Stewart et al., 2002). In a small Norwegian study of 145 stroke survivors discharged from hospital, apraxia and pathological emotional reactions were found to be the most important predictors of dependency in left-hemisphere and right-hemisphere stroke groups respectively (Sundet et al., 1988). Language impairment has also been found to predict minimal gains from rehabilitative efforts (Paolucci et al., 1998).
2.7. Cognition and motor control:

The field of motor control is directed at studying the nature of movement and how movement is controlled. Motor control is defined as the ability to regulate or direct the mechanism essential to movement. It addresses questions such as how does the central nervous system (CNS) organize the many individual muscles and joints into coordinated functional movement? How is sensory information from the environment and the body used to select and control movement? How do our perceptions of ourselves, the task we perform and the environment in which we are moving influence our movement behavior? What's the best way to study movement and how can movement problems be quantified in patient with motor control problem? (Shumway-cook & Woollacott, 2007).

Since movement is not usually performed in the absence of intend, cognitive processes are essential to motor control. Motor control includes perception and action systems that are
organized to achieve specific goals or intends. Thus, the study of motor control must include the study of cognitive processes as they relate to perception and action. So within the individual, many systems interact in the production of functional movement. While each of these components of motor control (perception, action and cognition) can be studied in isolation, it's believed that a true picture of the nature of motor control cannot be achieved without a synthesis of information from all three (Shumway-cook & Woollacott, 2007).

The perceptual system monitors the state of the virtual world, maintains a coherent representation of it and provides this information to the cognitive and motor control systems. The cognitive system interprets its perceptual input, chooses appropriate goals, constructs and executes plans to achieve those goals and sends out motor commands. The motor control system implement those motor commands, controlling voice, locomotion, gaze & gesture and allowing manipulation of objects in the virtual world (Boden, 2006).

Cognitive processes refer to the capacity of the nervous system to store and process environmental information and to use this for the regulation of behavior. The automatized actions are probably performed with a minimum cognitive load, whereas vowel or complex actions are, for a large part, governed by cognitive mechanisms (Fawcus, 2000).

Skilled activities are characterized by more or less automatic and smooth performance, independent from cognitive and perceptual control but still requiring feedback and error-monitoring. Most of our actions such as standing, walking and reaching are performed without noticeable attention or effort as are the multitude of actions related to the activities of daily living. These actions are regulated by means of a mode of control requiring little or no information-processing capacity. Normally this is a fast and fluent process requiring no conscious involvement, but this fluency breaks down after damage to the system. In this case roles are no longer available to control the action and peripheral input is no longer able to feed the roles (Fawcus, 2000).

2.8. Activities of daily living:

Activities of daily living include activities such as self-care, personal hygiene, communication, ambulation, travel, sexual function and sleep. Any limitations in these activities should be related to physical disability and/or mental disorder. The quality of these activities is
judged by their independence, appropriateness, effectiveness and sustainability. It's necessary to define the extent to which the individual is capable of initiating and participating in these activities independent of supervision or direction (American medical association, 2001).

The examiner must assess not simply the number of activities that are restricted but the overall degree of restriction or combination of restriction. For example, a person who is able to cook and clean might be considered to have marked restriction of daily living activities if he/she was too fearful to leave home to shop or go to the physician office (American medical association, 2001).

A careful and competent functional assessment of patients provides information that is critical to ascertain how that patient's autonomy can be maximized through medical, social, mechanical and/or environmental manipulation. For this reason, the ability to function is a central focus of all health care management evaluations. It's not enough to know about patient's diagnosis because this information alone is insufficient to predict the impact of health problems on a person’s daily life. The ability to live as one chooses and to perform basic activities throughout the day is affected by a multitude of factors (health problems, attitude, environmental features, social roles, resources …etc.). Evaluation of a person’s functional status is key to help that person maintain his/her autonomy and quality of life because functional abilities are of paramount importance to overall health, well-being and potential need for services (Cress, 2007).

Functional ability is assessed through the measurement of the basic skills of role function. McDowell & Newell (1987) reported that scales measuring functional disability fall into two general categories: (1) activities of daily living (ADL) scales such as bathing, grooming, dressing, eating, transferring, toileting, and (2) instrumental activities of daily living (IADL) scales including handling financial matters appropriately, finding one’s way away from home and back and managing medication regimens. Larson, 1991 reported that the ADL scales are designed to measure health in the chronically ill and aged, whereas IADL scales measure less severely handicapped population and are used often in the general population.

There are many scales that measure ability to perform ADL with great degrees of accuracy. Many of these scales are concerned with more severe levels of disability, relevant to institutionalized patients and the elderly. During the 1970s, ADL concept was extended to
consider problems experienced by those living in the community, a field that has come to be termed instrumental activities of daily living (IADL). There is a continued effort to validate these scales; some of the commonly utilized, validated IADL and ADL scales are listed in tables 2 and 3 (American medical association, 2001).

Scales vary in their appropriateness for a given individual, based upon the level of impairment, body system affected and the degree of accuracy required. Some scales are most appropriate for an active, working population; others are more suited to a chronically ill, disabled population. Since there is no agreed-upon scale, a physician may choose the most appropriate of any of the validated scales for a more in-depth assessment of ADL. This obtains further information to supplement clinical judgment or to gain assistance in determining the impairment of an individual. (American medical association, 2001).

Barthel Index (BI) is one of the most commonly used scales to assess ADL. It consists of ten items that measure a person's daily function specifically the activities of daily living and mobility. These items include feeding, moving from wheelchair to bed and return, grooming, transferring to and from a toilet, bathing, walking on level surface, going up and down stairs, dressing; as well as; continence of bowels and bladder. The assessment can be used to determine a baseline level of functioning and can be used to monitor improvement in activities of daily living over time. The items are weighted according to a scheme developed by the authors. The person receives a score based on whether they have received help while doing the task. The scores for each of the items are summed to create a total score. The higher the score, the more independent the patient is (Herndon, 2006).
The Functional Independence Measure [FIM] (Table 2) is a measure of disability widely used in the United States. It was originally developed by uniform data systems in Buffalo, New York, based on a large database of patients discharged from rehabilitation facilities. FIM contains 18 items that are organized into six subscales and assess two dimensions: (1) Physical: eating, grooming, bathing, dressing, toiletry, bowel & bladder control, transferring and
ambulation. (2) Cognitive: communication, social interaction, problem solving and memory. Each of the 18 items is assessed on a seven-point scale ranging from one (requiring complete dependence) to seven (being completely independent). FIM has been extensively validated in patients who had either neurologic or orthopedic disabilities. FIM provides a more detailed assessment of the various functional abilities of the patients compared to Barthel Index. However, it's difficult to learn and the graduations between the seven-point assistance scale for each item are relatively poorly defined (Herndon, 2006).

The Index of independence in daily activities commonly referred to as the Katz ADL, was developed by Katz et al., (1963). The Index of independence in daily activities is the best known ADL scale. It was developed from observations over time of the chronically ill. Despite its popularity, this index has certain problems. The six functions measured are reduced to a single score which" means a loss of information about variability, because different patterns of restriction, with somewhat different implications, can be reduced to the same score". There are also other problems: important activities are omitted, such as walking; performance is graded on an ordinal scale; and the range of disabilities is limited, although the Katz ADL Index is sensitive to changes in declining health status, it is limited in its ability to measure small increments of change seen in the rehabilitation of older adults (Larson, 1991).

McDowell and Newell (1987) preferred the Barthel Index scale to the Index of independence in daily activities and the other ADL scales mentioned above. The authors seem to prefer it for its simplicity and its higher level of validity and reliability. The functions which are measured by Barthel Index provide a more complete measure of disability than does the Index of independence in daily activities.

The Barthel Index has a test re-test reliability of 0.89, an inter-rater reliability exceeding 0.95, a correlational validity of 0.74 to 0.90 and a consistently high correlation in predictive validity. The Barthel Index is a very good measure of functional disability (Larson, 1991).

2.9. Impact of Cognitive Impairment on Functional Abilities:

Decreased cognitive function is related to loss of independence in activities of daily living particularly in the older adult and the oldest old (Ensrud et al., 1994). Cognitive impairment affects the human ability to perform both ADLs and IADLs even in patients with
minimal cognitive impairment. Human’s ability to perform activities of daily living is as dependent on the cognitive skills as physical skills (Coster et al., 2007).

Carter et al., (1988); Lincoln et al., (1997) and Mercier et al., (2001) reported that there is a significant correlation between various components of the ADL and one or many particular cognitive components. Blaum et al., (2002) examined the cross-sectional association between low cognitive performance (LCP) and task-specific disability. Even after chronic disease and conditions were controlled, LCP had a significant association not only with all IADL tasks but also with mobility tasks, including walking across a room and climbing stairs. The same results are obtained from the study of Dodge et al., (2005).

In the study of Mokashi (2005) which was done on 23 stroke patients, there was a positive correlation between cognition and ADL. The orientation correlated positively with motor Functional Independence Measure (FIM) among all subjects except one, with significance of p<0.01. The visual perception correlated with self care with significance of p<0.01 and p<0.05 respectively in all subjects. Correlation between visual perception and sphincter control was seen only in two subjects with the significance of p<0.05 and p<0.01 respectively. The visual perception correlated with mobility with most of the subjects except one, the level of correlation was significant at p<0.01. The visual perception correlated with locomotion with most of the subjects except one, the level of correlation was significant at p<0.01. This finding has been previously detected by Tatemichi et al (1994).

Stroke severity in acute stage and cognitive impairment at 18 months after stroke onset were associated with impairment in ADL and increased costs for utilization of care during the first year as shown in the study of Claesson et al., (2005). In this study, patients with cognitive impairment were more dependent on personal assistance in ADL and the costs per patient during the study were three times higher for patients with cognitive impairment.

Greiner et al., (1996) suggested that low normal cognitive function (i.e.: Mini-Mental State Examination scores of 24 to 27) may be a useful clinical indicator of older adults at increased risk for loss of independent physical function. Authors also suggested that people achieving low normal scores on the Mini-Mental State Examination should have their current physical function assessed. Secondary and tertiary preventive measures may be useful in
maintaining current levels of physical independence and obviating the need for more expensive in-home or institutional supports.

The assessment of complex ADL is probably useful for the diagnosis of mild cognitive impairment (Perneczky et al., 2006). In mild cognitive impairment, the slower speed of task performance is an important component and perhaps an early marker of functional change that would not be detected using traditional measurement of daily function (Wadley et al., 2008).

Chapter III
Subjects, Materials and Procedures
3.1. Subjects:

Thirty right handed Egyptian stroke patients participated in this study. Patients were randomly assigned into two groups:

1. Group A: included fifteen patients with left hemiparesis due to right cerebrovascular accident (CVA).
2. Group B: included fifteen patients with right hemiparesis due to left CVA.

Fifteen normal healthy subjects, matched in age, were also included as a control group (group C).

Patients were diagnosed clinically and radiologically as having hemiparesis due to CVA in the domain of the carotid system. They were recruited from the Department of Neurology, Faculty of Medicine, Cairo University and from the outpatient clinic of the Faculty of Physical Therapy, Cairo University In the period from May to September 2009. The whole procedure was explained for every patient and oral consent was obtained from every patient to insure complete satisfaction.

3.1.1. Inclusion criteria:

- Hemiparesis due to vascular insult in the territory of the carotid system diagnosed by Neurologist and confirmed by CT and/or MRI of the brain.
- Mild degree of spasicity in the affected upper and lower limb (grade 1 & 1+ according to modified Ashwarth scale).
- The patients’ ages ranged from 45 to 60 years.
- Duration of illness ranged from three to 18 months.
- Both sexes participated in this study.
- Medically and psychologically stable patients.

3.1.2 Exclusion criteria:
• Hemiparesis due to any cause other than vascular insult.
• Hemiparesis due to vertebrobasilar stroke.
• Visual, auditory and other neurological disorders.
• Pre-stroke cognitive problems and mental subnormalities.
• History of previous strokes.
• Patients receiving medications that may affect cognition.
• Depression.
• Illiterate patients.
• Uncooperative patients.
• Age above 60 to minimize the effect of aging on cognitive function.

3.2. Instrumentations:

3.2.1. Mini Mental State Examination [MMSE] (Appendix 1):

Mini Mental State Examination (MMSE) includes 11 items, divided into two sections:

- The first section requires verbal responses to orientation, memory, and attention questions.
- The second section requires reading & writing and covers ability to name something, follow verbal and written commands, write a sentence and copy a polygon.

All questions are asked in the order listed and can be scored immediately by summing the points assigned to each successfully competed task, the maximum score is 30. Details of scoring have occasioned considerable discussion. For example, it was originally proposed that counting backwards by sevens could be replaced by spelling “world” backwards. The cutting point most commonly used to indicate cognitive impairment deserving further investigation is 23/24. A score from 23-30 is considered as Normal cognition / a score between 19-23 is considered as Borderline / a score <19 is considered as Impaired cognition (Folstein et al., 1975).

3.2.2. RehaCom:
RehaCom manufactured by (Schuhfrted, model No. 454V, D-14482 potsd am, Karl-Liepknecht, Austria) is a comprehensive and sophisticated system of procedures for computer-assisted cognitive assessment and rehabilitation. RehaCom is a software package that helps to assess and train different cognitive areas (figure 2). In order to cover the various deficits which can result from brain damage, procedures have been developed for the following assessment dimensions: (1) Attention concentration; (2) Reactive behavior; (3) Logical reasoning and (4) Figural memory.

Patients typically use the RehaCom custom panel (a special keyboard with simple, large and clear keys) figure (3). Alternatively, if required, the system may be operated with a conventional computer keyboard, mouse or touch screen. In this study the custom panel was used with all patients. This input panel has six bid keys (four large white keys expressing up, down, right and left directions to choose the right answer and two large green keys (OK) to confirm the choice); two special keys (red key for emergent stop and yellow one for more information about the procedure) and one joystick. Attention concentration and logical reasoning items were chosen to be evaluated at this study.

The computer is neutral observer providing value-free comments on the patient’s performance and giving error specific feedback if required. A range of feedback modalities can be set in parametric menu: (1) Acoustic feedback; (2) Visual feedback and (3) Text/Auto stops.
**Fig. (2):** A Computer-based cognitive rehabilitation device (RehaCom), model No. 454V, D-14482 potsd am, Karl-Liepknecht, Austria

(Manual of RehaCom)

**Fig. (3):** The RehaCom custom panel “special key board”, Model No. 454V, D-14482 potsd am, Karl-Liepknecht, Austria
3.2.3. Barthel Index (Appendix 2):

Barthel Index (BI) consists of 10 items that measure a person's daily function specifically the activities of daily living and mobility.

The items include: feeding, moving from wheelchair to bed and return, grooming, transferring to and from a toilet, bathing, walking on level surface, going up and down stairs, dressing, continence of bowels and bladder.

The assessment can be used to determine a baseline level of functioning. The items are weighted according to a scheme developed by the authors. The person receives a score based on whether they have received help while doing the task. The scores for each of the items are summed to create a total score. The higher the score, the more independent the person is.

The values assigned to each item are based on time and amount of actual physical assistance required if a patient is unable to perform the activity. Because of the time required to attend an incontinent patient and since he is not socially acceptable, continence was weighted heavily.

A patient scoring 100 BI is continent, feeds himself, dresses himself, gets up out of bed and chairs, bathes himself, walks at least a block, and can ascend and descend stairs. This does not mean that patient is able to live alone: the patient may not be able to cook, keep house, and meet the public, but the patient is able to get along without attendant care. A score of 0 is given in all of the activities when the patient cannot meet the criteria as defined (Van Der Putten et al., 1999).

3.3. Procedures:

All patients (group A and B) were evaluated through using Mini Mental State Examination (MMSE), RehaCom and Barthel Index (BI) orderly. While normal subjects in group C was evaluated using RehaCom only.
Patients were subjected to the following assessment:

1. Clinical evaluation including careful history taking.

2. Radiological investigation including non contrast Computed Tomography and/or Magnetic Resonance Imaging (MRI) of the brain to document the presence of vascular insult in the domain of the carotid system.

3. The practical part of this study was conducted through three steps:

- **Step 1: Assessment of cognitive function using MMSE;**
  - MMSE was conducted for each patient at the cognition laboratory of the Faculty of Physical Therapy, Cairo University.
  - MMSE was conducted at a comfortable sitting position on chair with back support and suitable seat height compared to the table in front of the patient.
  - The patients were asked to write and draw by the non affected hand if they can’t do this by the affected one.
  - Reading items were written in clear and suitable font.
  - Items of copying were drawn with clear size.
  - Scores were recorded for each item and then the total score was calculated.

- **Step 2: Assessment of cognitive function using the RehaCom:**
  - RehaCom was carried out at the cognition laboratory for evaluating attention concentration and logical reasoning items.
  - Groups A, B and C were evaluated.
  - Every subject assumed a comfortable sitting position on a chair with suitable height in front of the screen figure (4).
  - The device and the procedure were explained in details for each patient before starting evaluation to be aware about the testing procedure.
  - Every subject was trained on using the device to be familiar with it before actually starting the evaluation session.
- For patients, the non affected upper limb was used for answering the tasks by pressing the simple keys of the custom panel.
- Attention concentration test consists of 24 levels of difficulties each composed of an average of 22 subtests.
- Logical reasoning test consists of 23 levels of difficulties each composed of 20 subtests.
- In both tests, every subject was evaluated starting from level one and when the subject successfully finished this level, the testing then progress to the next level of difficulty.

**Fig. (4):** A patient being tested by RehaCom

- **The assessment parameters:**
  
a) **Attention concentration:**
  
  - Length of session:
The length of session was chosen to be the maximum session length available by the system 60 mins. with five mins. rest in between.

- **Limited solution time:**

  This parameter was deactivated during the assessment to measure the patient’s maximum and minimum reaction time and compare it with the normative data obtained from the evaluation of group C.

**b) Logical reasoning:**

- **Length of session:**

  The length of session was chosen to be 25-35 mins. as recommended by the device’s manual.

- **Maximum solution time:**

  The solution time was chosen to be the maximum time available by the system which is 300 seconds.

- **Task description in the procedure of attention concentration (Manual of RehaCom):**

  - A separately presented picture was compared to a matrix of pictures. The one picture resembles it in every detail is to be found. The picture in the matrix, either concrete objects (fruits, animal, faces, etc.), geometric objects (circles, rectangles, triangles in different sizes and orders), or letters and numbers are harder to differentiate the higher the level is.

    - The training screen is divided into two parts. One part contains one separate picture of an object. The other part represents the matrix which contains according to the level of difficulty: three pictures (one by three matrices), six pictures (two by three matrices) or nine pictures (three by three matrices) **Figure (5a, b and c).** The patient had to recognize the picture shown
separately and selects the one that resembles it in every detail from the matrix by means of a big button.

- When using the big buttons of the panel, an orange frame marks a picture in the matrix. By means of the buttons the patient move the frame to the picture the patient chooses, and then the selection is confirmed by pressing OK button on the panel.

- After selecting a picture the procedure evaluates the choice and lights up a green sign “CORRECT” or a red sign “INCORRECT” Figure (6 a and b). The performance bar changes according to the reaction quality. This performance bar grows or shrinks with every correct or incorrect choice respectively. These procedures continue until the patient fails to achieve three correct choices at a certain level. Such level of attention and concentration was recorded as the maximum achievement level of this patient.

Fig. (5a): 3 pictures (1 by 3 matrices)
Fig. (5b): 6 pictures (2 by 3 matrices)

Fig. (5c): 9 pictures (3 by 3 matrices)

Fig. (5): RehaCom system screens for attention concentration test.
Fig. (6a): Green Sign; Correct Answer

Fig. (6b): Red sign; Incorrect Answer

Fig. (6): RehaCom screen signs for attention concentration test
Task description In the procedure of logical reasoning (Manual of RehaCom):

- The system for logic thought uses problem solving exercises. The types of exercises used are 'completion of a series'. The analysis of the problem situation and of its elements is primary. By increasing the difficulty of the logic succession and increasing supposition of several logic structures, the patient should learn to recognize the concepts underlying each problematic situation and to use these concepts to solve the logic problem.

- In the assessment, a picture series was shown with simple graphic figures. The patient had to find the relationship between the individual links of the series and through induction derive a rule (figure reasoning) which clarifies what the next link of the series is. When the patient has established what the rule is, then he had to select the relevant picture from a matrix of pictures. The matrix of pictures can be used by the patient to check that he has derived the correct rule.

- The picture series appeared in the upper part of the screen figure (7a and b). The pictures consisted of a minimum of seven pictures and a maximum of 14. If the picture number was greater than seven, the logical succession was distributed over two series or rows which were spaced out above each other. A tear-off edge clarified that the entire logical succession must be solved from the two single series. The picture series is solved when the correct picture is placed in the empty field. This field is the one beside the large red arrow. The correct picture was selected from a matrix of pictures in the lower part of the screen.

- The patient switched to a lower level of difficulty if the column didn’t reach the red marker. Otherwise, as the green marker had been reached but not exceeded the same performance level was repeated.

- On several levels a performance feed back was provided, if the correct picture was selected, a green “CORRECT” field appears for a short time. If a wrong decision was taken, a light was shown “Error analysis”, which reflected each individual error on one or more red mistakes field.

- After the patient had worked through the number of items per level from the task, a percentage was computed. The percentage represents the number of the correct decisions in relation to the number of the items (number of errors shouldn’t exceeds 15% of the total number
of the subtests of each level). When the percentage exceeded the threshold “continue to the next level”, the patient then moved to a higher level of difficulty. When the percentage had fallen below the threshold “repeat the previous level” then it indicates that this is the maximum level that the patient had reached.

- At the end of each attention concentration test trial a print out report was obtained including tables and graphs that contain the following information:

1. Level: the level of difficulty reached.
2. Maximum reaction time in milliseconds.
3. Minimum reaction time in milliseconds.

**Fig. (7a):** A picture series of seven pictures

**Fig. (7b):** A picture series of twelve pictures
- At the end of each logical reasoning test trial a print out report was obtained including tables and graphs that contain the following information figure (8):

1. Level: the level of difficulty reached.
2. Quartile reaction time 1 (in milliseconds).
3. Quartile reaction time 3 (in milliseconds).

- **Step 3: Assessment of functional activities using Barthel Index (BI):**

  - Barthel Index was conducted while the patient is sitting in a comfortable position on chair with back support and suitable seat height.
Barthel Index was conducted for every patient (groups A and B) at the cognition laboratory of faculty of Physical Therapy, Cairo University.

Patients’ relatives were involved in this assessment procedure to insure the real level of function of the patient as some patients may deny their level of disability.

Level of independence in functional activities governs the score of each item and then the total scored was calculated for every patient.
3.4. Data Analysis and Statistical Design:

- Descriptive statistics in the form of mean and standard deviation were used.

- Analysis of variance (ANOVA) was used to compare the mean age between the three groups.

- Unpaired t-test was used to compare the mean duration of illness between groups A and B and to compare the results obtained from RehaCom, MMSE and BI between group A and B. Besides, it was used to compare the results obtained from RehaCom between groups A & C and B & C.

- Mann-Whitney test which is a non parametric t-test was used to compare RehaCom outcome measurements between two groups (A and B, A and C, B and C. separating results of males from results of females).

- The alpha point of 0.05 was used as a level of statistical significance (when P = 0.08 classed as "trend wise significant", P = 0.05 is usually classed as “significant”, P = 0.01 as “highly significant”, and P = 0.001 as “very highly significant”) (Betty and Jonathan, 2003).

- Spearman’s correlation coefficient (r) was used to correlate between RehaCom mean scores and mean scores of MMSE, BI and side of lesion. Spearman’s correlation coefficient was also used to correlate between MMSE mean scores and mean scores of RehaCom, BI and side of lesion. Values of (r) ranged from 0 (no correlation), 0-0.2 (very low and probably meaningless), 0.2-0.4 (a low correlation that might warrant further investigation), 0.4-0.6 (a reasonable correlation), 0.6-0.8 (a high correlation) and 0.8-1 (a very high correlation) (Betty and Jonathan, 2003).
Chapter I

Introduction

Cognition is the internal structures and processes that are involved in the acquisition and use of knowledge, including sensation, perception, attention, learning, memory, language, thinking and reasoning. Cognitive processes are not localized to discrete portion of the brain but are a direct result of interactions among anatomically connected brain areas (Purves et al., 2007).

Cognitive impairment can include a progressive deterioration of intellectual ability (e.g., dementia), impairment of memory, aphasia, apraxia, one of the agnosias or changes in executive function (e.g., initiating, planning, and regulating task performance) (Cavanagh et al., 2002).

Cerebrovascular diseases are the second most common cause of cognitive decline and dementia. Stroke can have a massive effect on cognitive function, and dementia is a common outcome of stroke. Cognitive impairment in stroke patients has a prevalence of 17-38%. Cognitive impairment is associated with many short and long term poorer outcomes including poorer functional recovery and has a significant confounding factor to physical rehabilitation (Saxena, 2006).

The mini mental state examination (MMSE) is a brief, quantitative measure of cognitive status in adults. MMSE can be used to screen cognitive impairment, to estimate the severity of cognitive impairment at a given time, to follow the course of cognitive changes in an individual over time and to document an individual’s response to treatment (Folstein et al., 1975). The MMSE has been shown to be sensitive to the effects of a variety of neurological disorders including cerebrovascular disease, and it can be used to predict and track cognitive function in longitudinal studies and clinical trials (Dunitz, 2002).

RehaCom is a comprehensive and sophisticated system of procedures for computer-assisted cognitive assessment and rehabilitation. This practical tool assists the physical therapists in the assessment and rehabilitation of cognitive disorders that affect attention concentration, figural memory, reaction behavior and logical reasoning. Developed from the ground-up as an assessment and therapy tool - not a computer game - RehaCom can be used in the assessment and therapy of cognitive disorders (www.hasomed.de, 2008).
Barthel index (BI) measure a person's daily function specifically the activities of daily living and mobility. The assessment can be used to determine a baseline level of functioning and can be used to monitor improvement in activities of daily living over time. The scores for each of the items are summed to create a total score. The higher the score, the more independent the person is (Van Der Putten et al., 1999).

1.1. Statement of the problem:

Does cognitive impairment have an impact on functional abilities of stroke patients?

1.2. Purpose of the study:

The purpose of this study is to investigate the impact of cognitive impairment on functional abilities of stroke patients.

1.3. Significance of the study:

One third of surviving patients of stroke present with persistant cognitive impairment that has subsequent impact upon quality of life. Cognitive impairment can slow rehabilitation and increase the admission period in hospital. Long-term effects of cognitive impairment are as or more significant than physical impairments in re-establishing family and social activities (Cavanagh et al., 2002). Some aspects of neuropsychological functioning (e.g., presence of neglect, aphasia, anosognosia, verbal memory and attention deficits) show promise as a mean of predicting post stroke functional outcomes. This suggests that these areas of neuropsychological functioning may be targeted for rehabilitative efforts (Barker-Collo and Feigin, 2006).

There are various researches that studied the relationship between cognition and functional abilities in stroke (Tatemichi et al, 1994; Pedersen et al, 1996; Kathleen et al, 1998; Mokashi, 2005). In the current study using new objective equipment as RehaCom in combination with traditional screening tool as (MMSE) help to raise more accurate scores considering the level of cognitive abilities. The importance of the current study for physical therapy arise from the fact that the effect of cognition on functional activities plays a fundamental role in rehabilitation program and can manipulate the whole plane of treatment.
1.4. **Delimitations:**

This study was delimited to the following:

- Thirty stroke patients due to cerebrovascular accident (CVA) in the domain of the carotid system divided to fifteen patients with right CVA and other fifteen patients with left CVA were selected from the department of neurology, Faculty of Medicine, Cairo University and from the outpatient clinic in the Faculty of Physical Therapy, Cairo University.
- The patient's ages ranged from 45-60 years.
- Duration of illness ranged from three to 18 months.
- The patients were medically stable with mild degree of spasticity (grade 1 and 1+ according to modified Ashwarth scale).

1.5. **Limitations:**

This study was limited by the following factors:

- Small sample size.
- Small number of females compared to males in the studied group.
- Choosing the sample of educated patients without selecting a specific level of education.

1.6. **Basic assumption:**

It was assumed that:

- The patient's motivation and cooperation were the same for every patient.
- The calibration of the equipment used in this study was precise and insured to minimize any source of error.

1.7. **Hypothesis:**

It is hypothesized that there is no impact of cognitive impairment on functional abilities of stroke patients.
Definition of Terms

1. Attention Concentration:

The cognitive process of selectively concentrating on one aspect of the environment while ignoring other things. Attention has also been referred to as the allocation of processing resources.

2. Figural memory:

The ability to store, retain, and recall information related to figures.

3. Index stroke:

The acute onset of a focal neurological deficit attributable to vascular disease of the brain that lasted >24 hours and was supported by CT scan (normal or relevant infarct) performed within 1 week of symptom onset (Moroney et al., 1998).

4. Logical reasoning:

Three kinds of logical reasoning can be distinguished: deduction, induction and abduction.

Given a precondition, a conclusion, and a rule that the precondition implies the conclusion, they can be explained in the following way:

- **Deduction** means determining the conclusion. It is using the rule and its precondition to make a conclusion. Example: "When it rains, the grass gets wet. It rains. Therefore, the grass is wet." Mathematicians are commonly associated with this style of reasoning.

- **Induction** means determining the rule. It is learning the rule after numerous examples of the conclusion following the precondition. Example: "The grass has been wet every time it has rained. Therefore, when it rains, the grass gets wet." Scientists are commonly associated with this style of reasoning.

- **Abduction** means determining the precondition. It is using the conclusion and the rule to support that the precondition could explain the conclusion. Example: "When it rains, the grass gets wet. The grass is wet, therefore, it may have rained." Diagnosticians and detectives are commonly associated with this style of reasoning.
5. Psychometrics:

The field of study concerned with the theory and technique of educational and psychological measurement, which includes the measurement of knowledge, abilities, attitudes, and personality traits. The field is primarily concerned with the construction and validation of measurement instruments, such as questionnaires, tests, and personality assessments.

6. Reaction behavior:

The human response to external stimulation.

7. Reaction time:

The elapsed time between the presentation of a sensory stimulus and the subsequent behavioral response.

8. Quartile reaction time 1:

The shortest time was taken by the subject to solve the task of logical reasoning (in milliseconds).

9. Quartile Reaction time 3:

The longest time was taken by the subject to solve the task of logical reasoning (in milliseconds).
Chapter II

Review of Literature

In this chapter the following headings will be reviewed:

2.2. Assessment of cognition.
2.3. Stroke and its complications.
2.4. Cognitive impairment after stroke.
2.5. Neuropsychological outcomes of stroke.
2.6. Predicting functional stroke outcome from neuropsychological data.
2.7. Cognition and motor control.
2.8. Activities of daily living.
2.9. Impact of cognitive impairment on functional abilities.

2.1. Cognition:

Cognition refers to the integrated functions of the human mind that together result in thought and goal-directed action. Simply, cognition involves the acquisition, processing and application of information in daily life. Cognition is at the core of an individual’s essence or personhood. Cognition not only influences what person chooses to do, but also it dictates how an experience is remembered and interpreted (Radomski & Latham, 2007).

Human cognition can be referred as a system, which means that it’s a set or assemblage of things, connected, associated or interdependent, so as to form a complex unity. Like all systems, the cognitive system can be split into a series of highly connected, but nevertheless potentially separable subsystems. These are the major components or parts of the cognitive system, and correspond to the major sets of operations that the human mind performs. These subsystems are the main elements of cognition including memory, vision, language, attention and skills. During examining the elements of cognition, the dynamic and changing nature of these elements especially memory, perception and skills should be considered. (Hampson & Morris, 1996)
Memory is the quintessential changing system in that, like a good library, new materials is continually entering and being classified. However, unlike a library, it seems that retrieving materials from memory, the act of remembering itself, can some time result in changing to stored information. Memory is always in a process of flux; we cannot hold it still nor stop it from altering. Perception is constantly changing too. The more we see, the more we learn to see. Human skills develop and improve with time; they are rarely static. (Hampson & Morris, 1996).

2.1.1. Memory:

Memory, which is one of the central elements of cognition broadly refers to information storage and retrieval. There are many conceptions of the way this processes occurs (Baddeley, 1990; Lezak, 1995). Figure (1) shows Atkinson and Shiffrin’s information-processing model of memory (1971) which highlights stages of acquisition and employing new knowledge and skills.

![Diagram of information-processing model of memory](image)

**Figure (1):** The diagram of information-processing model of memory (Atkinson and Shiffrin`s, 1971)

The information-processing memory is explained as following:

- **Sensory registers:** information from the environment is briefly (milliseconds) held in registers or stores specific to the human senses (Lezak, 1995). This registration stage has been called the intake valve for determining what data from the environment are ultimately stored. This phase is influenced by acuity of the senses (such as hearing and vision), affective set and perception (Radomski & Latham, 2007).
● **Short term memory:** the short term phase of the information processing has many labels: immediate memory, short term memory and working memory. The term "working memory" connotes the effortful deployment of cognitive resources during this stage. In short, for input from sensory registers to proceed to storage in long term memory, it must be the subject of deliberate concentration in working memory for approximately 30 seconds. Without this focused attention, the memory trace decays and the memory is not retained (Lezak, 1995).

Unlike long term memory, which is thought to have an infinite capacity, working memory has a restricted holding capacity of seven plus or minus two chunks of information (Miller, 1956). In addition to its role in information processing, working memory is the seat of conscious thought used in concentration and problem solving. Based on electrochemical activity in the brain, working memory reflects the contribution of attention to the memory process (Radomski & Latham, 2007).

● **Long term memory:** whereas data in working memory has a short shelf life, information in long term memory can be stored for a lifetime (Glover et al, 1990). When someone remember information (an event that occurred an hour ago or a year ago), data are located and retrieved from long term memory and are held for conscious attention and thought in limited-capacity working memory. Storage in long term memory is based on relatively permanent changes in brain cell structure, although there does not appear to be a single local storage sit for stored memory (Lezak, 1995).

Long term memory is thought to consist of two subsystems, declarative memory and procedural memory. Declarative memory holds factual information, which is subdivided into episodic memory (knowledge of personal information and events) and semantic memory (knowledge of facts about the world). Procedural memory holds information related to knowing how to do things. It allows us to learn and perform skilled motor actions (Eysenk & Keane, 1990).

2.1.2. **Vision:**

Human perceives by seeing, hearing, touching, tasting and smelling. Vision is one of the major perceptual systems through which people learn about the world around them. Vision is clearly a vital system that plays a great role in cognitive function. Human cognition is a unique
blend of powerful memory systems, highly developed pattern recognition abilities and general purpose skills to interact with changing environment. All of these elements of cognition are important in the case of vision. Vision involves more than pattern of recognition, it draws on memory & drives and is informed by action (Hampson & Morris, 1996).

2.1.3. Language:

Language is central to human activity. Once language has been acquired, it is used almost continuously. People talk to other people, write to them and when not talking, writing, listening or reading, much of the remaining time is spent in thinking in which an inner voice using familiar words is normally experienced. As language is studied, more of its complexities become more apparent (Hampson & Morris, 1996).

Language is composed of semantics, syntax and pragmatics. The study of semantics is the study of the meaning of the words both by themselves and when put together to form sentences and long statement. Language is essentially a mean of communication and it’s successful only if meaning is communicated by the person uttering a statement to the person who hears or reads this statement. The study of meaning and its communication is therefore central to the study of language (Hampson & Morris, 1996).

A traditional model of verbal communication has been called the code model. In this model, thoughts are translated by some linguistic encoding device into words which can be transmitted either vocally or in writing. These messages are then received by the hearer and decoded via a linguistic decoding device into the appropriate thought and intended meaning, such a code model is inadequate to describe fully and properly the nature of language communication. It does, however, form a useful starting point for identifying some of the steps involved in language communication (Lezak, 1995).

The study of syntax is the study of the appropriate and inappropriate ordering of words in any particular language. It is rare for anyone to utter single words at time. Normally, humans speak in single sentences. For communication to be possible it’s necessary for the words to be put together to satisfy the rules of the particular language being spoken. The third domain of the study of language to be considered here is pragmatic. The study of pragmatic investigates why, in a given situation, a particular utterance is chosen. Why, for example, do people say "lovely weather" on a rainy day and how do other people understand that this is an ironic comment on
the weather rather than a crazy and false statement? The pragmatic aspects of language and the influence of the particular situation the speaker and the listener are in have become important issue in the study of language (Hampson & Morris, 1996).

The code model of verbal communication assumes that thought is the currency of the cognitive system and that language is used merely as a code for communication to another person. Thoughts are translated into words so that they can be transmitted to the other individual (Hampson & Morris, 1996).

2.1.4. Attention:

Attention is the deployment of mental resources for concentration. Each person is thought to have a limited capacity for consciously attending to information a hard-wired upper limit that dictates how many inputs can be simultaneously processed (Radomski & Latham, 2007).

According to Sohlberg & Mateers (2001), there are four levels of attention:

1. Sustained attention, which is the capacity to maintain attentional performance over time.
2. Selective attention, which occurs when an individual concentrates on one set of stimuli while ignoring competing stimuli.
3. Divided attention, which allows a person to respond to more than one task at a time and is a more complex mental skill than sustained and selective attention.
4. Alternating attention, which is necessary when one flexibly shifts attention between multiple operations.

2.1.5. Skill:

Skill is a very important element of cognition. When talking about skill sensory-motor and cognitive skills are usually considered. Car driving is an example of a sensory-motor skill in that what is involved is the use of sensory information in the selection and modification of the movements that person makes. Crossword solution is a cognitive skill that is not dependent upon learning how to use sensory input to continuously modify movement. Instead, it is dependent on how to carry out a cognitive task. The distinction is important since not all conclusions that may be reached about one type of skill will necessarily apply to the other. Nevertheless, there seem to be many similarities in the processes that underlie both types of skill acquisition (Lezak, 1995).
For many skills it's easy to explain what must be done at a gross level, the problem is in performance. To ride a bicycle, all that one have to do is to sit on the saddle, push around the pedals with feet and turn the front wheel with the handlebars to steer, it's simple, but perhaps not when person try it for the first time. Riding a bicycle actually depends on knowing how to do many things that are easy to take for granted: knowing how to balance, knowing how to compensate for turns in the wheel when steering or when looking behind for traffic, knowing how much effort to put into each foot while turning the pedals. The example of riding a bicycle illustrates the difference between declarative (or propositional) and procedural knowledge. (Hampson & Morris, 1996).

Declarative knowledge is knowing facts and knowing that something is the case. Procedural knowledge is knowing how to do something perhaps with no conscious ability to describe how it’s done. Describing to someone what riding a bicycle entails, in declarative terms, is not sufficient for them to acquire the procedural knowledge needed to ride one. On the other hand, processing procedural knowledge of how to ride bicycle does not equip anyone with declarative knowledge. Most of subjects who can ride bicycle will not possess the declarative knowledge. The skill acquisition is the study of the acquiring of the procedural knowledge. One of the problems facing driving instructors and sports coaches is the difficulty of translating what is often a simple amount of declarative knowledge into procedures that the trainees can actually carry out. Their main tool is practice, but practice with as much guidance as possible. (Hampson & Morris, 1996).

Although the major elements and subsystems of cognition mentioned above are examined separately, these elements work smoothly together for the benefits of the system as a whole. Without perception, no new information could enter memory; without memory, things seen could not be interpreted in term of familiar categories. Similarly, language might sharpen material in memory and perhaps alter how we perceive things, but without memory and perception, the ability to use language would never develop in the first place (Radomski & Latham, 2007).

If only three aspects of human cognition had to be chosen, they would be: first, its powerful memory subsystems which support virtually all cognitive abilities from perceiving to thinking; second, its remarkable pattern recognition abilities which arise not just in perception,
but are used in memory, language, thinking, problem solving and skills; third, its flexible ability to interact and communicate with a changing world. Memory pattern recognition and (perceptual-motor, cognitive and communicative) skills lie in the core of cognition (Radomski & Latham, 2007).

Using cognition is heavily dependent on the elements of cognition. The term "using cognition", in which the emphasis changes from studying the cognitive system to what can be done with it, the mind and elements of cognition can be used for remembering, planning & acting, reading, problem solving and decision making. The number of possible applications of the human mind is of course potentially infinite, but to look at each task that the mind can do is often less interesting than using a range of related tasks to draw conclusions about its general operating characteristics or the sorts of typical jobs we can do with the cognitive system (Hampson & Morris, 1996).

Cognition clearly influences the selection, performance, analysis and learning of everyday activities. In addition to its central role in occupational functioning, a person's cognitive function influences the acquisition of new activities of daily living (ADL) (Radomski & Latham, 2007). Sandstrom & Mokler (1999) described cognitive function as a key outcome variable for persons with severe motor stroke. Hanks et al., (1999) found that cognition predicted functional abilities and social integration six months after discharge from acute rehabilitation. To identify and remove barriers that interfere with occupational functioning and to anticipate rehabilitation outcomes, occupational therapists should examine patients' cognitive function as a part of comprehensive occupational therapy assessment.

2.2. Assessment of cognitive functions:

Cognitive state examination can be crucial for producing evidence of an organic component in a mental illness. The number of tests and procedure available for processing cognitive function is rather be wildering and it's therefore helpful to acquire a standard routine. This also has a value in building up the clinician's experience of the different tests and the meaning to be put on failure in various situations (Lishman, 1998).

Most of the brief short hand cognitive tests employed by the psychiatrist lack adequate standardization and validation. Indeed when their value has been tested the tests have often,
taken individually, proved to be remarkably inefficient in distinguishing between organic and functional psychiatric illness. It is proved to be closely related to educational level and general intelligence, some are markedly affected by increasing age and other by emotional disturbance. Some of the more detailed psychometric procedures elaborated by psychologists are clearly superior for the task of identifying organic psychiatric disorder, but are too cumbersome for use in every patient (Lishman, 1998).

Nevertheless the routine tests available to the clinician have a definite value for their own. These tests have the important virtue of throwing a very wide net and touching upon a number of facets of cognitive function in a reasonably concise manner. In the course of administrating them, the examiner also picks up numerous indirect clues (e.g.: the patient behavior during attempts at the tests and the nature of the approach) which provide important information in themselves (Lishman, 1998).

Cognitive function should be assessed systematically (Chow & Maclean, 2001 and Registered Nurse Association of Ontario [RNAO], 2003). Without systematic assessment, the pathological conditions go unchecked and the individuals with these conditions face much greater accelerated and long term cognitive and functional decline and death (Fick & Foreman, 2000; Fick et al., 2002; Hopkins & Jackson, 2006 and Lang et al., 2006).

It is clear that the assessment of cognitive function is the first and most crucial step in a cascade of strategies to prevent, reverse, halt or minimize cognitive decline (Cummings et al., 1994 and Delis et al., 2000). Since clinicians need to measure the cognitive performance of patients, a very large body of tests has accumulated over the past to self questionnaires for the carer (Chow & Maclean, 2001 and RNAO, 2003).

The cognitive function test should be reproducible, valid in practice and readily comprehensible and the best battery should encompass a set of modules of tests assessing specifically different cognitive domains that one can use or combine to meet the patient/research protocol`s specific needs (Cappa et al., 2008).

Cappa et al., 2008 mentioned that psychometric cognitive function tests can be classified in different ways, for example:
* Cognitive (e.g.: *stroop test; stroop, 1935*), behavioral (Lebert et al., 1998) and quality of life (Naglie et al., 2006) tests and questionnaires.

* Global (e.g.: *Mini Mental State Examination; Folstien et al. 1975*), multidomain tests sensitive to different cognitive processes (categorical fluency involving both executive functions, working memory and semantic memory) or domain-specific tests (e.g.: Gruber and Buschke memory tests; Gruber et al., 1988).

* A psychometric approach in which the performance of the subject is compared to validated norm (e.g.: *IQ measurement with WAIS; Wechsler, 1997*) versus concept-driven cognitive evaluation (dissociated performance for producing proper names compared to common names).

Many neuropsychological assessment batteries were developed but Wechsler Adult Intelligence Scale-Revised (WAIS-R) is the most popular and commonly used tests. Wechsler defined intelligence as "the global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment". WAIS-R is a general test of intelligence. It consists of 11 subtests divided into two parts, verbal and performance, it takes 60-90 mins to administer and is used at patients aged between 16 - 74 years old (Franzen, 2000).

WAIS-R consists of six verbal subtests and five performance subtests. The verbal tests are: Information, Comprehension, Arithmetic, Digit Span, Similarities, and Vocabulary. The performance subtests are: Picture Arrangement, Picture Completion, Block Design, Object Assembly and Digit Symbol. The scores derived from this test are a Verbal IQ (VIQ), a Performance IQ (PIQ) and a Full Scale IQ (FSIQ). Test-retest reliability coefficients affirm the excellent reliability of the Verbal and Full Scales, and show Performance IQ to be quite acceptable (0.89 to 0.90). Test-retest coefficients for the subtests confirm the reliability of all tasks except Object Assembly and Picture Arrangement. Wechsler Adult intelligence scale III [WAIS-III] is the third edition of the original WAIS which along with reorganization of subtests and updated normative data, has expanded the age range to 89 years old (Franzen, 2000).

The Neuropsychological Assessment Batteries [NAB] is a comprehensive, integrated, modular battery of 33 new neuropsychological tests developed to assess a wide array of neuropsychological skills and functions in patients (ages 18-97 years) who have known or suspected disorders of the central nervous system. The individual tests are grouped into six modules: Attention, Language, Memory, Spatial, Executive Functions and Screening (which
allows the clinician to determine which of the other five domain-specific modules are appropriate to administer to an individual patient). The NAB have excellent psychometric properties: (a) include extensive normative and validation data, (b) provide clinical information that meet the needs of a broad range of modern referral sources, (c) offer two equivalent forms that reduce practice effects and facilitate reevaluation. The examiner can administer the entire NAB for a comprehensive evaluation of neuropsychological functioning in less than four hours (Stern & White, 2003).

Many dementia batteries have been developed. The Mini Mental State Examination (MMSE) is one of these batteries. It was developed as brief tool for grading the level of cognitive impairment in the elderly as well as in screening for dementia. It's a 30 point scale, consisting of several orientation questions (ten points), a registration and recall task (six points), an attention task (five points), a multistep command (three points), two naming tasks (two points), a repetition task (one point), a reading comprehension task (one point), a written sentence (one point) and a visual construction task (one point). The reading comprehension task involves the patient reading a sentence and performing the command. The construction task involves copying interlocking pentagons. These items are generally printed on the form used to facilitate administration of the test. This test is rapid to administer (10 mins) and it is strongly influenced by age and education (Herndon, 2006).

The Addenbrookes's Cognitive Examination [ACE] (Appendix 5 and 14) is essentially an elaboration of MMSE that was designed to be more sensitive to amnestic syndromes and to isolated frontal or linguistic deficits than most mental status examination, yet it's not as complex as Mattis dementia rating scale. It takes about 15-20 mins to administer (Lezak et al., 2004).

The ACE consists of six sections; Orientation (ten items from MMSE); attention/mental tracking (eight points: repetition of three words and five serial seven subtraction); episodic and semantic memory (35 points; recall of three words after distraction, learning of a seven-element name and address over three trials, recall of the address and name after five min. delay and giving the name of four government figures); verbal fluency (up to seven points each for phonemic[“P” words] and semantic [animals] fluency); language (28 points: naming items depicted in 12 lines drawing; comprehension of three simple commands [two spoken and one written], two complex commands, and a three steps command; repeating three words & two
phrases; reading two five-item lists composed of either regular and irregular words [each scored all or non]; and writing a sentence); and visuospatial ability (five points: copying intersecting pentagons, copying a cube and drawing a clock face with numbers and hands set to ten past five) (Lezak et al., 2004).

Single domain tests are frequently used. These tests include memory, attention, perception, language, construction, reasoning and executive function. The stroop test is one of the most commonly used diagnostic tools when determining an attention problem. It involves focusing on one particular feature of a task, while blocking out other features. It includes three phases: (1) read words of colors printed in black, (2) name the color of colored patches, (3) name the color of the ink of works designating colors (where the meaning of the words & color of ink are different) (Lezak et al., 2004).

Formal neuropsychological testing, which usually includes tests of multiple cognitive domains, is the best approach to evaluate mildly impaired patients when a diagnosis is in question. Psychometric tests with well-defined properties may offer the best way of documenting progression in cognitive impairment, although the briefer instruments have been used for the same purpose. Development and validation of neuropsychological batteries that can be used in longitudinal studies will be important for future clinical trials. Psychometric batteries that minimize ceiling effect are necessary for patients with mild cognitive impairment. A disadvantage of many instruments used to assess cognition is that severely impaired subjects may not be able to perform the test (Herndon, 2006).

2.2.1. Mini Mental State Examination (MMSE):

Among all these instruments assessing cognitive function, Mini Mental State Examination (MMSE) that was developed by Folstein et al., (1975) is the most frequently recommended instrument and the most widely used. MMSE has been the most commonly used screening instrument for cognitive functioning for more than twenty five years because it’s brief. It consists of eleven items and takes about 7 to 10 minutes to complete and it’s easy to use. MMSE is composed of items assessing orientation, attention, memory, concentration, language and constructional abilities (Capezuti et al., 2007).
Although MMSE is designed to produce a global score for rating cognitive status, it contains some tasks which could be classified as "domain it specific". It is within the capabilities of older adults, and yields a single summary score that can be used as the primary cognitive outcome measure for a clinical trial (Guiloff, 2001).

Despite MMSE considered the best available method for screening of cognitive impairment, Tombaugh & McIntyre (1992) stated that MMSE is significantly influenced by education (individuals with less than eighth grade education commit more errors), language (individuals for whom English is not their primary language commit more errors), verbal ability (MMSE can only be used with individuals who can respond verbally to questioning) and age (older people do less well). Borson et al., (2005) contended that despite these limitations, it remains the most frequently recommended and most commonly used tool to assess cognitive functioning. Herndon, 2006 insured that MMSE makes an excellent choice for office use. By keeping its limitations in mind, clinicians can use it to advantage of assessing cognitive status.

Test-retest reliability of MMSE has been examined in many studies and the results of test-retest reliability ranged from 0.80-0.92 (Anthony et al., 1982; Dick et al., 1984; Thal et al., 1986; Fillenbaum et al., 1987 and Uhlmann et al., 1987). Inter-rater reliability has also been widely studied. Molloy et al., 1991 reported inter-rater reliability of 0.69 and 0.78. In a sample of 15 neurological inpatients, inter-rater reliability gave a Pearson correlation of 0.95 and a Kendall coefficient of 0.63.

Although factor analyses have used different types of sample and differing versions of the MMSE, they commonly identify factors relating to orientation, memory and attention (Folstien et al. 1975). In terms of content validity, the MMSE measures eight of the 11 main aspects of cognitive status; it omits abstraction, judgment and appearance (Foreman, 1987).

2.2.2. RehaCom:

RehaCom is a comprehensive and sophisticated system of procedures for computer-assisted cognitive assessment and rehabilitation. This practical tool helps the therapist in the assessment and rehabilitation of cognitive disorders that affect attention concentration, figural memory, reaction behavior and logical reasoning. This system developed from the ground-up as
an assessment and therapy tool - not a computer game - RehaCom assists in the assessment and therapy of cognitive disorders. It has been developed continuously since 1986 by HASOMED GmbH (Inc, Ltd) in Magdeburg, Germany with experienced neuropsychologists. Now, this system used in over 1000 hospitals and practices across Europe (www.hasomed.de, 2008).

RehaCom procedures have been clinically validated by means of extensive studies in Germany although much of that literature is in the German language. RehaCom has been developed and updated since 1986 by Hasomed GmbH in Magdeburg, Germany together with experienced neuropsychologists. All procedures are based on the original concept of Professor Hans Regel and are theoretically founded as the approach utilized in the German health model. RehaCom is a very comprehensive tool to assist with assessment and therapy for Cognitive disorders. It will make life easier but will never be a substitute for a competent clinician (www.anatomicaconcept.com, 2008).

The patient or the subject can work with RehaCom on a regular computer (executable with Windows NT4/98/ME/2000/XP). The system makes scientifically funded tasks available to the patient over the screen and loudspeakers. These tasks are solved by the patient in the sense of an assessment of cognitive functions. The operation of RehaCom is easy to learn for the affected person. Motor or seriously cognitively handicapped people can use the RehaCom board - a special keyboard with simple, large and clear keys. Alternatively, a usual computer keyboard can be used. Also for the therapist handling RehaCom is very fast and easy to learn. In all procedures the operation interface is identical (www.hasomed.de, 2008).

2.3. Stroke and its complications:

Cerebrovascular accident (CVA) or "stroke" is the third leading cause of death and the major cause of adult disability. Stroke is often a sudden and devastating event causing changes in the patient's lifestyle and exerting major psychological and economic stress on the person and the family member (Turner et al., 2002).

Stroke may be classified into two general types; ischemic and hemorrhagic. Ischemia refers to disruption of the blood supply to an area of the brain, which eliminates its supply of glucose and oxygen resulting in an infarct or area of dead tissue. Infarction may occur as a result of thrombosis, where a plug forms blocking of blood flow. About 50% of stroke is caused by
cerebral thrombosis, which falls into two subcategories: large-vessel thrombosis and small-vessel thrombosis. Blood flow may be blocked by an embolism, where a plug of thrombic material travels through arteries as they branch off into smaller vessels and eventually lodges in a blood vessel that is too small for it to pass through. Approximately, 30% of stroke is caused by cerebral embolism. Lacunae are defined by the size of the area affected rather than by etiology (Mohr et al., 1978).

Hemorrhagic stroke, which accounts for approximately 20% of all strokes, may be due to intracerebral hemorrhage or subarachnoid hemorrhage. An intracerebral hemorrhage (also called a parenchymal hemorrhage) occurs when a diseased artery within the brain ruptures, flooding the surrounding brain tissue with blood. Most signs and symptoms associated with intracerebral hemorrhage are caused by the compression of brain structures and blood vessels. Subarachnoid hemorrhage (bleeding into the skull or cranium that occurs when a blood vessel on the surface of the brain ruptures and bleeds into the meninges) usually follows the rupture of an aneurysm or an arteriovenous malformation (Mohr et al., 1978).

The impairment associated with CVA can be motor, perceptual, sensory, cognitive and psychological. This impairment can have an impact on the individuals’ daily occupation. Deficits in concentration, memory, decision making and sequencing, for example; will have a direct bearing on the individual’s ability to respond to treatment and retain new information. Difficulty with speech or comprehension can cause the person to feel isolated and lacking of self worth and to appear uncooperative to treatment. It's therefore important to identify cognitive deficits in order to discriminate it from perceptual or speech impairments (Turner et al., 2002).

For prediction of physical recovery following stroke, the type, lesion size and stroke severity have been examined, and the focus was on survival as an indicator of positive outcome. Wide variation exists in the reported survival rates for patients with stroke and its subtypes. Generally the findings indicate that those with ischemic stroke (especially lacunar) have relatively high short and long-term survival rates, while survival after hemorrhagic stroke is less likely (Barker-Collo & Feigin, 2006).

In addition to the subtype, a number of stroke-related and demographic factors appear to influence outcome; as well as; the relationship between neuropsychological functioning and outcome. Positive functional outcomes from stroke have been significantly related to absence of
prior stroke, less severe initial neurological deficit, stroke involving cortical structures and left hemispheric lesions (Macciocchi et al., 1998). Thus, an individual with right hemisphere lesions, with multiple focal lesions, with history of previous stroke or with severe initial neurological deficits would be expected to have a poorer outcome following stroke (Barker-Collo & Feigin, 2006).

Loss of consciousness has also been linked to stroke outcome. Ebrahim and Harwood (1999) stated that “impaired consciousness has stood the test of time as an adverse prognostic sign for survival”, a conclusion that agreed with Bonita and Beaglehole (1988) and Anderson et al., (1994).

In addition, younger age has been correlated with better recovery from stroke (Kalra, 1994; Giaquinto et al., 1999; Jehkonen et al., 2000). Ween et al., (1996) found that patients under age of 55 at stroke onset returned home more often than older patients. They noted that age is a reliable predictor of outcome mainly in young and very old stroke patients.

Low education was found to be inversely correlated with making improvements in a rehabilitation program (Lehmann et al., 1975). In a study done by Nyrkkoe, (1999) the influence of education and age on the outcome of 115 stroke patients was examined. He found that patients with higher education had better compensation abilities, and that younger patients with more reserve capacity had more potential to be improved. However, education played no significant role regarding outcome after stroke in another study done by. Nonetheless, Turner et al., 2002 stated that a young and well-educated patient having a single stroke is expected to have a more positive outcome than recurrent small vessel disease in an older, less educated individual.

The disablement resulting from stroke is frequently an admixture of physical and mental problems. The latter may be attributable directly to the sustained brain damage, or largely represent the individual’s reaction to the handicaps imposed upon him. In either event his personality make-up and his life situation can have a profound effect on overall adjustment to the disability, and the mental components of the picture will often be decisive in determining the level of success achieved in rehabilitation. It's therefore unfortunate that little attention has been directed to cognitive and psychiatric problems of stroke and to the ways in which these problems interact with the physical disabilities (Lishman, 1998).
2.4. Cognitive impairment after stroke:

Defects in the intellect or other higher cortical function are among the more serious sequelae of stroke. These defects cause delaying and often gravely compromising attempts at rehabilitation. Such elements in the clinical picture may be less immediately obvious than hemiplegia or other physical handicap, yet often prove to be the factors which are truly responsible for failure to regain independence. Thus among patients who become long-stay invalids, permanently confined to chair or bed, paralysis by itself rather seldom accounts for their incapacity and may even contribute little towards it (Lishman, 1998).

Mental impairment that may follow a single stroke usually proves to be focal in nature once the initial clouding of consciousness has cleared. For some time, however, global confusion and disorientation may be much in evidence, and can be slow to clear when the cerebral damage has been extensive. It may be aggravated by anoxia from congestive cardiac failure or respiratory infection, or be attributable in part to the patient's difficulty in coping with new found barriers to communication with his environment. As the situation improves the true extent of cognitive dysfunction is revealed. The longer the clouding consciousness has persisted the more likely that residual mental deficits are severe and extensive (Lishman, 1998).

Considerable difficulty may be encountered in assessing the extent of global intellectual impairment, particularly if the patient is dysphasic or with marked constructional difficulties. Agitation, depression or apathy in the early stages of stroke may give a false impression of cognitive impairment. A circumscribed amnesia syndrome due to posterior cerebral infarction may be wrongly attributed to cognitive impairment in such patients (Lishman, 1998).

In a review of 45 hemiplegic patients, Adams & Hurwitz (1963) showed that physical disability, such as dense paralysis or limited exercise tolerance, accounted for failure to respond to treatment in less than half of them. In 40% of patients, severe residual paralysis and sensory defects were accompanied by varying degrees of generalized intellectual impairment and a correspondingly high rate of incontinence. Failure to respond to treatment seemed to derive from impaired comprehension, difficulties in communication, inattentiveness and lack of spontaneous effort. Those patients were frustrated by preservation and couldn’t assimilate or retain instructions. Most of these infarctions had occurred in the distribution of the middle cerebral artery of the dominant hemisphere. Ten further patients showed neglect of the affected limbs or
even denied that they were in any way abnormal. Some disowned their hemiplegic limbs or complained of bizarre changes within them. The latter had at first given a superficial impression of alert and responsible behavior, which was later belied by defective grasp, inattentive lapses and persistent incontinence. Seven were mainly in capacitated by postural imbalance which had often led to profound loss of confidence. Other patients showed severe receptive dysphasia, apraxia of gait or emotional disturbance with catastrophic reactions.

Disturbances of language accompany two-thirds of patients with left hemispheric lesions, may be even without paralysis. They contribute alarm addict handicap and source of frustration, frequently outlasting recovery of motor function. Patient with expressive loss but good comprehension will in general make much better adjustment than when understanding is faulty. Apraxic disturbance may persist as a barrier to rehabilitation when motor paralysis has cleared, particularly an apraxia of gait. Thus patients with dominant hemisphere infarction appear to make a quick recovery from hemiparesis, but fail to regain a normal pattern of walking and postural control (Adams, 1967).

Disturbed awareness of the self or space commonly occurs after right hemisphere lesions than left. Neglect of the left half of external space may be accompanied by left sensory inattention, neglect or unawareness of body parts, or frank denial of disability (Lishman, 1998). Occasionally, however, exceptions are found and such symptoms result from left hemisphere lesions leading to a complex admixture of deficits: for example, Welman (1969) reported a right handed man who had a left parietotemporal infarction, suffered from right hemiplegia, aphasia for some hours, apraxia, hemisomatognosia, and anosognosia for the right side of the body, left unilateral spatial agnosia, visual constructive apraxia, left-right disorientation, loss of memory and finger agnosia in both hands.

The more florid aspect of anosognosia, involving verbal denial or disowning of paralysed limbs, usually subsides over several weeks, but neglect and inattention may endure. After severe infarction in the non-dominant hemisphere a characteristic pattern may emerge, providing immense difficulties for effective rehabilitation the patient has a dense hemianopia, hemiplegia and hemianesthesia but lacks insight into his predicament, may admit to nothing wrong with the left limbs or disown the arm. Sometimes this persists even after quite good recovery of power and the patient makes no constructive attempts to walk. Persistent incontinence is a common
accompaniment, adding to the poor prognosis for recovery of independence and social reliability (Adams, 1967).

Improvement over time in specific cognitive and perceptual disabilities may be expected to follow the course of decelerating curve. The percentage return of function gradually diminishing as time after stroke increases. In general most improvement can be expected within the first six months, but wide variation is seen. The influence of affective and motivational factors is often profound, delaying full recovery until several years have gone by. A considerable longer period must usually be allowed for the optimal resolution of dysphasia, visuospatial or topographical defects than of physical disabilities such as hemiplegia. The ultimate level achieved will depend crucially on the amount of brain tissue destroyed, the number of separate deficits involved and on the multitude of factors peculiar to the individual which dictate his adaptive capacity (Lishman, 1998).

The neglect and visuospatial function related to cognition can be seen either in the right or left strokes but it’s more severe in right than in left stroke Voos & Ribiero do Valle (2007). Sunderland et al., (1999) stated that visuospatial deficits were predictive of dexterity error rates for the right CVA and that the errors observed on the dexterity tasks suggested problems of visual attention or spatial judgment. There was no such association in the left CVA. They also stated that although these results are not completely clear cut, they are consistent with the proposal that visuospatial deficits were the major cause of dexterity errors after right but not left hemisphere damage. The results of Sunderland et al., (1999) agreed with many researches indicating reduction in the accuracy of rapid reaching for targets due to mild visual neglect or spatial disorientation after right hemisphere damage as the researches of Goodale et al., 1990 and Winstein & pohl, 1995.

Lezak & Loring, (2004) mentioned that spatial performance of right hemisphere damaged patients is adversely affected by lesions occurring anywhere in a fairly wide area while those patients with left hemisphere damage, with relatively sever damage to a well defined area, show impaired performance on spatial tasks. The author also hypothesized more diffuse representation of functions in the right hemisphere and more focal representation in the left. Moreover, lesions outside the right hemisphere’s sensorimotor area can contribute to motor deficits. But in the left hemisphere, motor deficits occur only with lesions involving the
sensorimotor area. Additionally, right hemisphere is more diffusely organized than the left which have been provided by the evidence that visuospatial and constructional disabilities of patients with right hemisphere damage do not significantly differ regardless of the extensiveness of damage.

**Lezak & Loring, (2004)** also showed the cognitive alterations with lateralized lesions when they stated that the most obvious cognitive defect associated with left hemisphere damage is aphasia and other left hemisphere disorders including: verbal memory or verbal fluency deficits, concrete thinking, specific impairments in reading or writing and impaired arithmetic ability. While for right hemisphere, perceptual deficits particularly left-sided inattention phenomena and those involving degraded stimuli or unusual presentations, are not uncommon. The visuospatial perceptual deficits that trouble many patients with right lateralized damage can affect different cognitive activities which show up as difficulty copying designs, making constructions and discriminating pattern of faces. Patient with right hemisphere damage may have particular problems with spatial orientation and visuospatial memory such that they get lost, even in familiar surroundings, and can be slow to learn their way around new area.

**Walker et al., (2004)** emphasized that Patients with right hemisphere damage had problems in selecting the correct sleeve, self-monitoring their left side or covering the paretic shoulder, suggesting deficits in visuospatial perception or neglect. Patients with left hemisphere damage dressed the non-paretic arm first or showed a disorganized dressing strategy, suggesting impaired action control due to apraxia. Moreover, **Sunderland et al. (1999)** reported that ideomotor apraxia gave rise to characteristic dexterity errors after left hemisphere damage whereas visuospatial deficits were predictive of the type of dexterity errors seen in right hemisphere damaged participants.

**Godefroy & Bogousslausky, (2007)** emphasized that the most frequent deficit following right hemispheric strokes is hemi-spatial neglect where there is impaired or lost ability to react to or to process sensory stimuli in the hemispace opposite to the lesion side. They added that spatial neglect most frequently occurs following right hemisphere damage that involves parietal, temporo-parital, frontal, limbic and subcortical areas. Also they mentioned in particularly, at the cortical level, that these lesions include the angular and supramarginal gyri of the inferior parietal lobe, the temporo-parietal junction, the superior temporal gyrus and the inferior &
middle frontal gyri. While aphasia is considered the most important cognitive impairment that occurs following left hemisphere strokes.

Stein et al., (2009) stated that the neglect is a common and severely disabling neurobehavioral disorder that associated with isolated right hemisphere injury. He also emphasized that electrophysiological findings and functional brain imaging studies suggested that whereas the left hemisphere attends primarily to the right side or in a rightward direction, the right hemisphere can attend to both sides or in both directions.

2.5. Neuropsychological outcomes of stroke:

Important, but often neglected outcomes of stroke are neuropsychological sequelae, which occur in nearly half of stroke survivors (Dennis et al., 2000). In one study of neuropsychological functioning carried out on 229 Dutch individuals assessed two-month post-stroke, it was found that over 70% of these patients suffered impaired information processing and at least 40% suffered difficulties with memory, visuospatial and constructive skills, language and arithmetic (Hochstenbach et al., 1998).

Sachdev and colleagues (2004) examined a sample of 170 stroke and transient ischemic attack (TIA) survivors at three to six months post-stroke in comparison to 96 age matched controls. Those identified from thorough neuropsychological and medical assessment as having ‘vascular dementia’ (i.e., having progressive cognitive deficits across a number of areas of functioning of vascular origin) produced disturbed performances across all cognitive domains with verbal memory, especially retention, being less impaired. Those identified as having ‘vascular cognitive impairment’ (i.e., having specific, non-progressive areas of cognitive deficit of vascular origin) but not dementia had similar, but less severe disturbances. The most contributes used to differentiate impaired from unimpaired individuals were abstraction, mental flexibility, information processing speed and working memory. Magnetic Resonance Imaging (MRI) variables (e.g., volume and number of infarctions) did not help in discriminating between subject groups.

Stephens et al., (2004) examined cognitive impairments in 381 stroke patients without dementia who had been classified as ‘with and without vascular cognitive impairment (VCI)’
aged over 75 years. When compared to 66 age matched controls, stroke survivors were found to have significant deficits in attention and executive function, even those without VCI. Those with VCI were significantly more impaired on tests of expressive language, memory and executive function than those without VCI. In those identified as having post-stroke dementia, a similar profile emerged, but deficits were more pronounced, particularly in terms of memory and orientation. Another study of Nyenhuis et al., 2004 done on post-stroke cognitive impairment, but not on post-stroke dementia, reported similar findings of significant post stroke cognitive impairment across various areas of cognitive functioning.

While various aspects of neuropsychological deficits have been the focus of research in selected subgroups of stroke patients, there is a lack of population-based studies on neuropsychological impairment in stroke survivors, and neither a profile of long-term neuropsychological deficits nor its relationship with other long-term functional outcomes have been established (Barker-Collo & Feigin, 2006). In a population-based study in South London (Patel et al., 2002), it was found that cognitive impairment at four years after stroke was associated with greater likelihood of death during further follow-up and with greater disability (Barthel Index <15). However, in this study cognitive impairment was assessed by means of Mini-Mental State Examination (MMSE) only and the study suffered from a measurement bias. Similarly, outcome was assessed as overall level of functional independence, and thus is unable to speak to wider outcomes such as caregiver burden or health related quality of life.

Short-term (three months) cognitive impairment was evaluated in a small population-based study (n=99) in Melbourne, Australia (Srikanth et al., 2003). The study revealed that mild to moderate stroke severity was associated with a significant risk of cognitive impairment at three months after stroke.

If specific stroke subtypes are shown to have differing neuropsychological outcomes, then the need for community and rehabilitation services, educational and interventional programs in stroke patients and their families could also be different. However, data on the long-term outcomes in survivors of different stroke subtypes are scarce, limited to one-year follow-up, and often inconsistent (Sturm et al., 2002).
Few population-based studies have investigated neuropsychological outcomes of stroke subtype. In a study done in Melbourne by Sturm et al., (2002) and carried out on ischemic stroke patients examined after 12 months of insult, handicap (measured by the London Handicap Scale) differed significantly with severity of disability (measured by the Barthel Index). No information on hemorrhagic stroke subtypes was provided in this publication.

In the Australian study (Hackett & Anderson, 2000), incomplete recovery at one year after subarachnoid hemorrhage was found in 46% of survivors, of which ongoing memory problems were recorded in 50%, mood abnormalities in 39%, and speech problems in 14%, while a substantial proportion of survivors had diminished level of health-related quality of life.

In another comprehensive literature review of unruptured intracranial aneurysms (the most common cause of subarachnoid hemorrhage), Towgood et al., (2004) strongly suggested inclusion of comprehensive neuropsychological tests in the assessment of those who have suffered vascular accidents. Other studies also suggested that neuropsychological deficits following stroke are more important determinants of functional outcomes than physical disability (Lynch et al., 1997; Zhu et al., 1998; Kotila et al., 1999; Bays, 2001; Hochstenbach et al., 2001 and Patel et al., 2002).

The literature linking neuropsychological functioning to outcome after a neurological event has focused on prediction of specific outcomes in small samples and assessing only specific areas of neuropsychological functioning, such as memory, attention, language, visuospatial or executive functions (Barker-Collo & Feigin, 2006). Robertson et al., (1997) reported that sustained attention is predictive of functional status two years post-stroke. Goldstein et al., (2001) found that assessments of memory significantly predict instrumental daily living skills in the elderly.

This accumulating body of evidence strongly suggests that appropriate neuropsychological rehabilitation (including preventive rehabilitation) may improve functional outcomes and reduce burden of stroke. Yet, post-stroke rehabilitation has traditionally focused on physical and occupational therapy; as well as; speech & language training, and paid relatively little attention to neuropsychological screening and rehabilitation (Finlayson, 1990; Paolucci et al., 1996 and Dobkin, 2005).
If neuropsychological impairment were to be independently associated with long-term outcomes and costs of stroke, it would lead to a major shift in stroke rehabilitation strategies and corresponding health services change. However, before any changes in the stroke rehabilitation, strategies can be introduced with confidence; more information on the significance of long-term neuropsychological outcomes in various stroke types should be available on a community level (Dobkin, 2005).

Further works are needed to differentiate not only the direct effect of neuropsychological impairment on outcome, but also its indirect effects. For example, there is a need to determine the relationship between neuropsychological impairment and factors such as medication compliance, ability to participate fully in rehabilitation, provision of paid care and the impacts of these on outcome (Barker-Collo & Feigin, 2006).

Neuropsychologically speaking, the division of stroke subtypes in relation to etiology is not optimal. The purpose of neuropsychological assessment is to quantify the behavioral deficits associated with damage incurred to various brain areas and structures. In this context it would seem more relevant to introduce stroke groupings that are based upon which aspect of vascular distribution has been disrupted (e.g., middle cerebral artery distribution), which are likely to be more integrally related to the behaviors being quantified. In those studies that have approximated this approach, the most common mean of patients grouping has been based upon hemispheric affection (Barker-Collo & Feigin, 2006).

2.6. Predicting functional stroke outcome from neuropsychological data:

Identification of predictors of particular long-term outcomes in stroke survivors would allow identification of individuals who may benefit from specific rehabilitation services. This may improve planning of stroke care and rehabilitation services and would facilitate better information provision to individuals and their families with regard to an individual’s potential for recovery and the likelihood of surviving in the long term. Ideally, predictive models of stroke outcomes should be based on population-based studies in which various potential predictors of stroke outcomes are described and adjusted for adequately; and where standard diagnostic criteria and validated standardized measures of outcomes are used (Sackett et al., 1991).
Although prognostic factors of stroke outcomes have been the subject of much discussion in many literatures (e.g., Kalra et al., 1993; Fiorelli et al., 1995; Paolucci et al., 1996; Adams et al., 1999 and Petty et al., 2000), there have been only few studies that addressed some aspects of this issue in the population-based setting (Taub et al., 1994; Hackett et al., 2000 and Hankey et al., 2002), and even fewer for studies of hemorrhagic stroke (Hackett et al., 2000).

The literature linking neuropsychological functioning to outcome after a neurological event has to date focused on prediction of specific outcomes in small samples and assessing only specific areas of neuropsychological functioning, such as memory, attention, language, visuospatial and executive functions. Few studies had examined the contribution of neuropsychological tests for prediction of post-stroke outcome is reviewed in table 1 (Barker-Collo & Feigin, 2006).

Generally, the studies identified can be grouped into those that examined the relationship between general/screening measures of neuropsychological ability (e.g., Mini Mental Status Exam) and outcome; and those that examine the relationship of specific neuropsychological abilities tests/deficits and outcome (Ozdemir et al., 2001).

MMSE has been used extensively in post-stroke patients as a measure of general cognitive functioning. Scores of MMSE at admission have been found to predict motor impairment at discharge. MMSE scores have also been found to correlate highly with anosognosia (Wagner & Cushman, 1994), and anosognosia itself is predictive of poor prognosis for hemiplegia (Giananello & Mattioli, 1992), mobility (Paolucci et al., 1996), and functional outcomes (Jehkonen et al., 2000).

It has been shown that specific areas of neuropsychological impairment are predictive of functioning and independence at discharge from acute stroke rehabilitation (Stewart et al., 2002). In a small Norwegian study of 145 stroke survivors discharged from hospital, apraxia and pathological emotional reactions were found to be the most important predictors of dependency in left-hemisphere and right-hemisphere stroke groups respectively (Sundet et al., 1988). Language impairment has also been found to predict minimal gains from rehabilitative efforts (Paolucci et al., 1998).
2.7. Cognition and motor control:

The field of motor control is directed at studying the nature of movement and how movement is controlled. Motor control is defined as the ability to regulate or direct the mechanism essential to movement. It addresses questions such as how does the central nervous system (CNS) organize the many individual muscles and joints into coordinated functional movement? How is sensory information from the environment and the body used to select and control movement? How do our perceptions of ourselves, the task we perform and the environment in which we are moving influence our movement behavior? What's the best way to study movement and how can movement problems be quantified in patients with motor control problems? *(Shumway-Cook & Woollacott, 2007)*.

Since movement is not usually performed in the absence of intend, cognitive processes are essential to motor control. Motor control includes perception and action systems that are
organized to achieve specific goals or intends. Thus, the study of motor control must include the study of cognitive processes as they relate to perception and action. So within the individual, many systems interact in the production of functional movement. While each of these components of motor control (perception, action and cognition) can be studied in isolation, it’s believed that a true picture of the nature of motor control cannot be achieved without a synthesis of information from all three (Shumway-cook & Woollacott, 2007).

The perceptual system monitors the state of the virtual world, maintains a coherent representation of it and provides this information to the cognitive and motor control systems. The cognitive system interprets its perceptual input, chooses appropriate goals, constructs and executes plans to achieve those goals and sends out motor commands. The motor control system implement those motor commands, controlling voice, locomotion, gaze & gesture and allowing manipulation of objects in the virtual world (Boden, 2006).

Cognitive processes refer to the capacity of the nervous system to store and process environmental information and to use this for the regulation of behavior. The automatized actions are probably performed with a minimum cognitive load, whereas vovel or complex actions are, for a large part, governed by cognitive mechanisms (Fawcus, 2000).

Skilled activities are characterized by more or less automatic and smooth performance, independent from cognitive and perceptual control but still requiring feedback and error-monitoring. Most of our actions such as standing, walking and reaching are performed without noticeable attention or effort as are the multitude of actions related to the activities of daily living. These actions are regulated by means of a mode of control requiring little or no information-processing capacity. Normally this is a fast and fluent process requiring no conscious involvement, but this fluency breaks down after damage to the system. In this case roles are no longer available to control the action and peripheral input is no longer able to feed the roles (Fawcus, 2000).

2.8. Activities of daily living:

Activities of daily living include activities such as self-care, personal hygiene, communication, ambulation, travel, sexual function and sleep. Any limitations in these activities should be related to physical disability and/or mental disorder. The quality of these activities is
judged by their independence, appropriateness, effectiveness and sustainability. It's necessary to define the extent to which the individual is capable of initiating and participating in these activities independent of supervision or direction (American medical association, 2001).

The examiner must assess not simply the number of activities that are restricted but the overall degree of restriction or combination of restriction. For example, a person who is able to cook and clean might be considered to have marked restriction of daily living activities if he/she was too fearful to leave home to shop or go to the physician office (American medical association, 2001).

A careful and competent functional assessment of patients provides information that is critical to ascertain how that patient's autonomy can be maximized through medical, social, mechanical and/or enviromental manipulation. For this reason, the ability to function is a central focus of all health care management evaluations. It's not enough to know about patient's diagnosis because this information alone is insufficient to predict the impact of health problems on a person's daily life. The ability to live as one chooses and to perform basic activities throughout the day is affected by a multitude of factors (health problems, attitude, enviromental features, social roles, resources …etc.). Evaluation of a person’s functional status is key to help that person maintain his/her autonomy and quality of life because functional abilities are of paramount importance to over all health, well-being and potential need for services (Cress, 2007).

Functional ability is assessed through the measurement of the basic skills of role function. McDowell & Newell (1987) reported that scales measuring functional disability fall into two general categories: (1) activities of daily living (ADL) scales such as bathing, grooming, dressing, eating, transferring, toileting, and (2) instrumental activities of daily living (IADL) scales including handling financial matters appropriately, finding one’s way away from home and back and managing medication regimens. Larson, 1991 reported that the ADL scales are designed to measure health in the chronically ill and aged, whereas IADL scales measure less severely handicapped population and are used often in the general population.

There are many scales that measure ability to perform ADL with great degrees of accuracy. Many of these scales are concerned with more severe levels of disability, relevant to institutionalized patients and the elderly. During the 1970s, ADL concept was extended to
consider problems experienced by those living in the community, a field that has come to be termed instrumental activities of daily living (IADL). There is a continued effort to validate these scales; some of the commonly utilized, validated IADL and ADL scales are listed in tables 2 and 3 (American medical association, 2001).

Scales vary in their appropriateness for a given individual, based upon the level of impairment, body system affected and the degree of accuracy required. Some scales are most appropriate for an active, working population; others are more suited to a chronically ill, disabled population. Since there is no agreed-upon scale, a physician may choose the most appropriate of any of the validated scales for a more in-depth assessment of ADL. This obtains further information to supplement clinical judgment or to gain assistance in determining the impairment of an individual. (American medical association, 2001).

Barthel Index (BI) is one of the most commonly used scales to assess ADL. It consists of ten items that measure a person's daily function specifically the activities of daily living and mobility. These items include feeding, moving from wheelchair to bed and return, grooming, transferring to and from a toilet, bathing, walking on level surface, going up and down stairs, dressing; as well as; continence of bowels and bladder. The assessment can be used to determine a baseline level of functioning and can be used to monitor improvement in activities of daily living over time. The items are weighted according to a scheme developed by the authors. The person receives a score based on whether they have received help while doing the task. The scores for each of the items are summed to create a total score. The higher the score, the more independent the patient is (Herndon, 2006).
The Functional Independence Measure [FIM] (Table 2) is a measure of disability widely used in the United States. It was originally developed by uniform data systems in Buffalo, New York, based on a large database of patients discharged from rehabilitation facilities. FIM contains 18 items that are organized into six subscales and assess two dimensions: (1) Physical: eating, grooming, bathing, dressing, toiletry, bowel & bladder control, transferring and
ambulation. (2) Cognitive: communication, social interaction, problem solving and memory. Each of the 18 items is assessed on a seven-point scale ranging from one (requiring complete dependence) to seven (being completely independent). FIM has been extensively validated in patients who had either neurologic or orthopedic disabilities. FIM provides a more detailed assessment of the various functional abilities of the patients compared to Barthel Index. However, it's difficult to learn and the graduations between the seven-point assistance scale for each item are relatively poorly defined (Herndon, 2006).

The Index of independence in daily activities commonly referred to as the Katz ADL, was developed by Katz et al., (1963). The Index of independence in daily activities is the best known ADL scale. It was developed from observations over time of the chronically ill. Despite its popularity, this index has certain problems. The six functions measured are reduced to a single score which" means a loss of information about variability, because different patterns of restriction, with somewhat different implications, can be reduced to the same score". There are also other problems: important activities are omitted, such as walking; performance is graded on an ordinal scale; and the range of disabilities is limited, although the Katz ADL Index is sensitive to changes in declining health status, it is limited in its ability to measure small increments of change seen in the rehabilitation of older adults (Larson, 1991).

McDowell and Newell (1987) preferred the Barthel Index scale to the Index of independence in daily activities and the other ADL scales mentioned above. The authors seem to prefer it for its simplicity and its higher level of validity and reliability. The functions which are measured by Barthel Index provide a more complete measure of disability than does the Index of independence in daily activities.

The Barthel Index has a test re-test reliability of 0.89, an inter-rater reliability exceeding 0.95, a correlational validity of 0.74 to 0.90 and a consistently high correlation in predictive validity. The Barthel index is a very good measure of functional disability (Larson, 1991).

2.9. Impact of Cognitive Impairment on Functional Abilities:

Decreased cognitive function is related to loss of independence in activities of daily living particularly in the older adult and the oldest old (Ensrud et al., 1994). Cognitive impairment affects the human ability to perform both ADLs and IADLs even in patients with
minimal cognitive impairment. Human’s ability to perform activities of daily living is as dependent on the cognitive skills as physical skills (Coster et al., 2007).

Carter et al., (1988); Lincoln et al., (1997) and Mercier et al., (2001) reported that there is a significant correlation between various components of the ADL and one or many particular cognitive components. Blaum et al., (2002) examined the cross-sectional association between low cognitive performance (LCP) and task-specific disability. Even after chronic disease and conditions were controlled, LCP had a significant association not only with all IADL tasks but also with mobility tasks, including walking across a room and climbing stairs. The same results are obtained from the study of Dodge et al., (2005).

In the study of Mokashi (2005) which was done on 23 stroke patients, there was a positive correlation between cognition and ADL. The orientation correlated positively with motor Functional Independence Measure (FIM) among all subjects except one, with significance of p<0.01. The visual perception correlated with self care with significance of p<0.01 and p<0.05 respectively in all subjects. Correlation between visual perception and sphincter control was seen only in two subjects with the significance of p<0.05 and p<0.01 respectively. The visual perception correlated with mobility with most of the subjects except one, the level of correlation was significant at p<0.01. The visual perception correlated with locomotion with most of the subjects except one, the level of correlation was significant at p<0.01. This finding has been previously detected by Tatemichi et al (1994).

Stroke severity in acute stage and cognitive impairment at 18 months after stroke onset were associated with impairment in ADL and increased costs for utilization of care during the first year as shown in the study of Claesson et al., (2005). In this study, patients with cognitive impairment were more dependent on personal assistance in ADL and the costs per patient during the study were three times higher for patients with cognitive impairment.

Greiner et al., (1996) suggested that low normal cognitive function (i.e.: Mini-Mental State Examination scores of 24 to 27) may be a useful clinical indicator of older adults at increased risk for loss of independent physical function. Authors also suggested that people achieving low normal scores on the Mini-Mental State Examination should have their current physical function assessed. Secondary and tertiary preventive measures may be useful in
maintaining current levels of physical independence and obviating the need for more expensive in-home or institutional supports.

The assessment of complex ADL is probably useful for the diagnosis of mild cognitive impairment (Perneczky et al., 2006). In mild cognitive impairment, the slower speed of task performance is an important component and perhaps an early marker of functional change that would not be detected using traditional measurement of daily function (Wadley et al., 2008).

Chapter III
Subjects, Materials and Procedures
3.1. Subjects:

Thirty right handed Egyptian stroke patients participated in this study. Patients were randomly assigned into two groups:

3. Group A: included fifteen patients with left hemiparesis due to right cerebrovascular accident (CVA).

4. Group B: included fifteen patients with right hemiparesis due to left CVA.

Fifteen normal healthy subjects, matched in age, were also included as a control group (group C).

Patients were diagnosed clinically and radiologically as having hemiparesis due to CVA in the domain of the carotid system. They were recruited from the Department of Neurology, Faculty of Medicine, Cairo University and from the outpatient clinic of the Faculty of Physical Therapy, Cairo University In the period from May to September 2009. The whole procedure was explained for every patient and oral consent was obtained from every patient to insure complete satisfaction.

3.1.1. Inclusion criteria:

- Hemiparesis due to vascular insult in the territory of the carotid system diagnosed by Neurologist and confirmed by CT and/or MRI of the brain.
- Mild degree of spasicity in the affected upper and lower limb (grade 1 & 1+ according to modified Ashwarth scale).
- The patients’ ages ranged from 45 to 60 years.
- Duration of illness ranged from three to 18 months.
- Both sexes participated in this study.
- Medically and psychologically stable patients.

3.1.2 Exclusion criteria:
• Hemiparesis due to any cause other than vascular insult.
• Hemiparesis due to vertebrobasilar stroke.
• Visual, auditory and other neurological disorders.
• Pre-stroke cognitive problems and mental subnormalities.
• History of previous strokes.
• Patients receiving medications that may affect cognition.
• Depression.
• Illiterate patients.
• Uncooperative patients.
• Age above 60 to minimize the effect of aging on cognitive function.

3.2. Instrumentations:

3.3.1. Mini Mental State Examination [MMSE] (Appendix 1):

Mini Mental State Examination (MMSE) includes 11 items, divided into two sections:
- The first section requires verbal responses to orientation, memory, and attention questions.
- The second section requires reading & writing and covers ability to name something, follow verbal and written commands, write a sentence and copy a polygon.

All questions are asked in the order listed and can be scored immediately by summing the points assigned to each successfully competed task, the maximum score is 30. Details of scoring have occasioned considerable discussion. For example, it was originally proposed that counting backwards by sevens could be replaced by spelling “world” backwards. The cutting point most commonly used to indicate cognitive impairment deserving further investigation is 23/24. A score from 23-30 is considered as Normal cognition / a score between 19-23 is considered as Borderline / a score <19 is considered as Impaired cognition (Folstein et al., 1975).

3.3.2. RehaCom:
RehaCom manufactured by (Schuhfrted, model No. 454V, D-14482 potsd am, Karl-Liepknecht, Austria) is a comprehensive and sophisticated system of procedures for computer-assisted cognitive assessment and rehabilitation. RehaCom is a software package that helps to assess and train different cognitive areas (figure 2). In order to cover the various deficits which can result from brain damage, procedures have been developed for the following assessment dimensions: (1) Attention concentration; (2) Reactive behavior; (3) Logical reasoning and (4) Figural memory.

Patients typically use the RehaCom custom panel (a special keyboard with simple, large and clear keys) figure (3). Alternatively, if required, the system may be operated with a conventional computer keyboard, mouse or touch screen. In this study the custom panel was used with all patients. This input panel has six bid keys (four large white keys expressing up, down, right and left directions to choose the right answer and two large green keys (OK) to confirm the choice); two special keys (red key for emergent stop and yellow one for more information about the procedure) and one joystick. Attention concentration and logical reasoning items were chosen to be evaluated at this study.

The computer is neutral observer providing value-free comments on the patient’s performance and giving error specific feedback if required. A range of feedback modalities can be set in parametric menu: (1) Acoustic feedback; (2) Visual feedback and (3) Text/Auto stops.
**Fig. (2):** A Computer-based cognitive rehabilitation device (RehaCom), model No. 454V, D-14482 potsd am, Karl-Liepknecht, Austria

(Manual of RehaCom)

**Fig. (3):** The RehaCom custom panel “special key board”, Model No. 454V, D-14482 potsd am, Karl-Liepknecht, Austria
3.3.3. Barthel Index (Appendix 2):

Barthel Index (BI) consists of 10 items that measure a person's daily function specifically the activities of daily living and mobility.

The items include: feeding, moving from wheelchair to bed and return, grooming, transferring to and from a toilet, bathing, walking on level surface, going up and down stairs, dressing, continence of bowels and bladder.

The assessment can be used to determine a baseline level of functioning. The items are weighted according to a scheme developed by the authors. The person receives a score based on whether they have received help while doing the task. The scores for each of the items are summed to create a total score. The higher the score, the more independent the person is.

The values assigned to each item are based on time and amount of actual physical assistance required if a patient is unable to perform the activity. Because of the time required to attend an incontinent patient and since he is not socially acceptable, continence was weighted heavily.

A patient scoring 100 BI is continent, feeds himself, dresses himself, gets up out of bed and chairs, bathes himself, walks at least a block, and can ascend and descend stairs. This does not mean that patient is able to live alone: the patient may not be able to cook, keep house, and meet the public, but the patient is able to get along without attendant care. A score of 0 is given in all of the activities when the patient cannot meet the criteria as defined (Van Der Putten et al., 1999).

3.4. Procedures:

All patients (group A and B) were evaluated through using Mini Mental State Examination (MMSE), RehaCom and Barthel Index (BI) orderly. While normal subjects in group C was evaluated using RehaCom only.
Patients were subjected to the following assessment:

4. Clinical evaluation including careful history taking.

5. Radiological investigation including non contrast Computed Tomography and/or Magnetic Resonance Imaging (MRI) of the brain to document the presence of vascular insult in the domain of the carotid system.

6. The practical part of this study was conducted through three steps:

- **Step 1: Assessment of cognitive function using MMSE;**
  - MMSE was conducted for each patient at the cognition laboratory of the Faculty of Physical Therapy, Cairo University.
  - MMSE was conducted at a comfortable sitting position on chair with back support and suitable seat height compared to the table in front of the patient.
  - The patients were asked to write and draw by the non affected hand if they can’t do this by the affected one.
  - Reading items were written in clear and suitable font.
  - Items of copying were drawn with clear size.
  - Scores were recorded for each item and then the total score was calculated.

- **Step 2: Assessment of cognitive function using the RehaCom:**
  - RehaCom was carried out at the cognition laboratory for evaluating attention concentration and logical reasoning items.
  - Groups A, B and C were evaluated.
  - Every subject assumed a comfortable sitting position on a chair with suitable height in front of the screen **figure (4).**
  - The device and the procedure were explained in details for each patient before starting evaluation to be aware about the testing procedure.
  - Every subject was trained on using the device to be familiar with it before actually starting the evaluation session.
- For patients, the non affected upper limb was used for answering the tasks by pressing the simple keys of the custom panel.

- Attention concentration test consists of 24 levels of difficulties each composed of an average of 22 subtests.

- Logical reasoning test consists of 23 levels of difficulties each composed of 20 subtests.

- In both tests, every subject was evaluated starting from level one and when the subject successfully finished this level, the testing then progress to the next level of difficulty.

![Image of a patient being tested by RehaCom]

**Fig. (4):** A patient being tested by RehaCom

- **The assessment parameters:**
  
  a) **Attention concentration:**
     
     - **Length of session:**
The length of session was chosen to be the maximum session length available by the system 60 mins. with five mins. rest in between.

- **Limited solution time:**

  This parameter was deactivated during the assessment to measure the patient’s maximum and minimum reaction time and compare it with the normative data obtained from the evaluation of group C.

b) **Logical reasoning:**

- **Length of session:**

  The length of session was chosen to be 25-35 mins. as recommended by the device’s manual.

- **Maximum solution time:**

  The solution time was chosen to be the maximum time available by the system which is 300 seconds.

  - **Task description in the procedure of attention concentration (Manual of RehaCom):**

    - A separately presented picture was compared to a matrix of pictures. The one picture resembles it in every detail is to be found. The picture in the matrix, either concrete objects (fruits, animal, faces, etc.), geometric objects (circles, rectangles, triangles in different sizes and orders), or letters and numbers are harder to differentiate the higher the level is.

    - The training screen is divided into two parts. One part contains one separate picture of an object. The other part represents the matrix which contains according to the level of difficulty: three pictures (one by three matrices), six pictures (two by three matrices) or nine pictures (three by three matrices) Figure (5a, b and c). The patient had to recognize the picture shown
separately and selects the one that resembles it in every detail from the matrix by means of a big button.

- When using the big buttons of the panel, an orange frame marks a picture in the matrix. By means of the buttons the patient move the frame to the picture the patient chooses, and then the selection is confirmed by pressing OK button on the panel.

- After selecting a picture the procedure evaluates the choice and lights up a green sign “CORRECT” or a red sign “INCORRECT” Figure (6 a and b). The performance bar changes according to the reaction quality. This performance bar grows or shrinks with every correct or incorrect choice respectively. These procedures continue until the patient fails to achieve three correct choices at a certain level. Such level of attention and concentration was recorded as the maximum achievement level of this patient.

Fig. (5a): 3 pictures (1 by 3 matrices)
**Fig. (5b):** 6 pictures (2 by 3 matrices)

**Fig. (5c):** 9 pictures (3 by 3 matrices)

**Fig. (5):** RehaCom system screens for attention concentration test.
Fig. (6a): Green Sign; Correct Answer

Fig. (6b): Red sign; Incorrect Answer

Fig. (6): RehaCom screen signs for attention concentration test
- Task description In the procedure of logical reasoning (Manual of RehaCom):

- The system for logic thought uses problem solving exercises. The types of exercises used are 'completion of a series'. The analysis of the problem situation and of its elements is primary. By increasing the difficulty of the logic succession and increasing supposition of several logic structures, the patient should learn to recognize the concepts underlying each problematic situation and to use these concepts to solve the logic problem.

- In the assessment, a picture series was shown with simple graphic figures. The patient had to find the relationship between the individual links of the series and through induction derive a rule (figure reasoning) which clarifies what the next link of the series is. When the patient has established what the rule is, then he had to select the relevant picture from a matrix of pictures. The matrix of pictures can be used by the patient to check that he has derived the correct rule.

- The picture series appeared in the upper part of the screen figure (7a and b). The pictures consisted of a minimum of seven pictures and a maximum of 14. If the picture number was greater than seven, the logical succession was distributed over two series or rows which were spaced out above each other. A tear-off edge clarified that the entire logical succession must be solved from the two single series. The picture series is solved when the correct picture is placed in the empty field. This field is the one beside the large red arrow. The correct picture was selected from a matrix of pictures in the lower part of the screen.

- The patient switched to a lower level of difficulty if the column didn’t reach the red marker. Otherwise, as the green marker had been reached but not exceeded the same performance level was repeated.

- On several levels a performance feedback was provided, if the correct picture was selected, a green “CORRECT” field appears for a short time. If a wrong decision was taken, a light was shown “Error analysis”, which reflected each individual error on one or more red mistakes field.

- After the patient had worked through the number of items per level from the task, a percentage was computed. The percentage represents the number of the correct decisions in relation to the number of the items (number of errors shouldn’t exceeds 15% of the total number
of the subtests of each level). When the percentage exceeded the threshold “continue to the next level”, the patient then moved to a higher level of difficulty. When the percentage had fallen below the threshold “repeat the previous level” then it indicates that this is the maximum level that the patient had reached.

- At the end of each attention concentration test trial a print out report was obtained including tables and graphs that contain the following information:

4. Level: the level of difficulty reached.
5. Maximum reaction time in milliseconds.
6. Minimum reaction time in milliseconds.

Fig. (7a): A picture series of seven pictures

Fig. (7b): A picture series of twelve pictures
Fig. (7): RehaCom screen for Logical Reasoning test

- At the end of each logical reasoning test trial a print out report was obtained including tables and graphs that contain the following information figure (8):

  1. Level: the level of difficulty reached.
  2. Quartile reaction time 1 (in milliseconds).
  3. Quartile reaction time 3 (in milliseconds).

Fig. (8): Graphs and tables expressing the results of logical reasoning by RehaCom.

- **Step 3: Assessment of functional activities using Barthel Index (BI):**

  - Barthel Index was conducted while the patient is sitting in a comfortable position on chair with back support and suitable seat height.
- Barthel Index was conducted for every patient (groups A and B) at the cognition laboratory of faculty of Physical Therapy, Cairo University.

- Patients’ relatives were involved in this assessment procedure to insure the real level of function of the patient as some patients may deny their level of disability.

- Level of independence in functional activities governs the score of each item and then the total scored was calculated for every patient.
6.4. **Data Analysis and Statistical Design:**

- Descriptive statistics in the form of mean and standard deviation were used.

- Analysis of variance (ANOVA) was used to compare the mean age between the three groups.

- Unpaired t-test was used to compare the mean duration of illness between groups A and B and to compare the results obtained from RehaCom, MMSE and BI between group A and B. Besides, it was used to compare the results obtained from RehaCom between groups A & C and B & C.

- Mann-Whitney test which is a non parametric t-test was used to compare RehaCom outcome measurements between two groups (A and B, A and C, B and C. separating results of males from results of females).

- The alpha point of 0.05 was used as a level of statistical significance (when \( P = 0.08 \) classed as "trend wise significant", \( P = 0.05 \) is usually classed as “significant”, \( P = 0.01 \) as “highly significant”, and \( P = 0.001 \) as “very highly significant”) (Betty and Jonathan, 2003).

- Spearman’s correlation coefficient \((r)\) was used to correlate between RehaCom mean scores and mean scores of MMSE, BI and side of lesion. Spearman’s correlation coefficient was also used to correlate between MMSE mean scores and mean scores of RehaCom, BI and side of lesion. Values of \((r)\) ranged from 0 (no correlation), 0-0.2 (very low and probably meaningless), 0.2-0.4 (a low correlation that might warrant further investigation), 0.4-0.6 (a reasonable correlation), 0.6-0.8 (a high correlation) and 0.8-1 (a very high correlation) (Betty and Jonathan, 2003).
Chapter V
Discussion

The present work was planned to investigate the possible impact of cognitive impairment on functional abilities of stroke patients. Thirty patients suffering from hemiparesis due to CVA in the domain of the carotid system and fifteen normal control subjects participated in this study. The patients divided equally into two groups, fifteen patients with right CVA (group A) and other fifteen patients with left CVA (group B).

General assessment of cognitive function was done using MMSE, while assessment of specific cognitive domain (attention concentration and logical reasoning) was done using RehaCom for both patients and control group. Functional assessment was done by Barthel Index (BI) for patients of groups A and B.

Age of patients in the present study was maximally limited to 60 years in order to minimize the effect of age on cognitive functions of the included subjects. Tatemichi et al., (1994) examined the cognitive performance of stroke patients and found that patients over age of 60 had poor performance of psychometric tests independent of the disease state. Haring, (2002) also reported that almost 30% of population over age of 65 have cognitive impairment, also Selnes & Vinters, (2006) documented that many old aged stroke patients (age over 60 years) have cognitive impairment even before the occurrence of stroke.

The duration of illness was selected to be not less than three months because almost all patients at the onset of stroke experience different degrees of cognitive affection at the acute stage. This selection matched with the study of Tatemichi et al., (1994) who had chosen his patients with duration of three months following the onset of stroke to perform neuropsychological testing to allow sufficient time for the acute effect of stroke on cognition to subside. Sachdev and colleagues (2004) also examined cognition in a sample of stroke patients with duration of three to six months post stroke. Another study was done in Cairo University by Talaat et al., (2006) had chosen patients three months post stroke to assess cognitive function.

Limiting the maximum duration of illness to be 18 months was to avoid the delayed cognitive decline that may occur after vascular insult due to other causes (e.g.: depression) and not as direct cause of stroke, this agreed with Haring, (2002) who stated that “even among
patients who remain cognitively intact after their index stroke, hospital based and population based study (e.g., Tatemichi et al., 1994; Kokmen et al., 1994) have revealed a significant risk for developing delayed cognitive impairment”. Beside, a study of Claesson et al., (2005) assessed cognitive impairment 18 months after the index stroke.

In the present study, the small number of females compared to males was attributed to the low incidence of stroke in females compared to males in this age group and that was previously documented by Stroke statistics Information, Charts and Graphs (2009) published by Clivir Learning Community Institute which emphasized that men’s stroke incidence rates are greater than women’s at the younger age but not at the older ages and that the male/female ratio is 5:4 at ages 55-64. Beside, the illiterate patients were excluded from this study as illiteracy has an impact on the normal values of cognition and so, the number of females was so limited due to the high rate of illiteracy among females in Egyptian community compared to males.

The small percentage of hemorrhagic stroke compared to ischemic is compatible with the study done by Clivir Learning Community Institute (2009) which stated that of all strokes, 87% are ischemic and 13% are haemorrhagic, and with the study done at Assiut University by Khedr et al., (2009) who emphasized that 84% of stroke patients had ischemic stroke while 16% had haemorrhagic stroke.

All comparisons were done in RehaCom first between groups as a whole then on basis of sex differences, so, males were compared to males and females were compared to females, this is due to the fact that males differ than females in cognitive abilities. This agree with study done in Ain Shams University by Sweed et al., (2009) which found that the mean cognitive tests scores of males were statistically significantly high than that of females.

Also a study done by Halpern, (2000) reported that girls excel at some verbal tasks whereas boys are superior at some mathematical and visuo-spatial tasks beside problem solving tasks. And that study exactly matched with the study of Proust-Lima et al., (2008) which proved that women performed better in tests involving verbal components, while men performed better in tests involving visuospatial skills.

In current study, a highly significant difference was observed between patients (GA and GB) and the controle group (GC) regarding the level of attention concentration and logical reasoning, being significantly lower in the patients groups. Also, a significant difference was
detected between patients (GA and GB) with control group (GC) regarding reaction times (minimum and maximum) of attention concentration and reaction time quarter 1 and 3 of logical reasoning, being significantly delayed in patients. This indicates the presence of cognitive impairment in stroke patients compared to normal subjects, a finding which agreed with previous studies (Hochstenbach et al., 1998; Srikanth et al., 2003; Sachdev et al., 2004; Stephens et al., 2004; Barker-Collo & Feigin, 2006).

When comparing the Rehacom parameters on basis of sex difference: it was found that, when comparisons were done between males patients (GA and GB) and control subjects (GC), that there were a highly significant difference regarding the levels of attention concentration and significant difference regarding both maximum and minimum reaction time. Beside, the highly significant difference that was found in levels of logical reasoning and the very highly significant difference in reaction time quarter 1 and 3 confirm the presence of different degrees of cognitive impairment associated with stroke. This agree also with the previous studies (Hochstenbach et al., 1998; Srikanth et al., 2003; Sachdev et al., 2004; Stephens et al., 2004; Barker-Collo & Feigin, 2006).

On the other hand, regarding the comparison between the female patients (GA and GB) and female of control group (GC), the only significant difference was observed in the level of attention and concentration, otherwise, no significant difference was detected between female patients and females of the controlled group. this could be attributed to the small sample of female subjects or as mentioned by Honjo et al., (2009) that association among persons with history of strokes was observed for males but not females probably due to gender differences in stroke subtypes and social support.

In the current study, some patients in groups A and B showed variable degrees of cognitive decline while others were within normal levels regarding attention concentration and logical reasoning parameters (Appendices 3 and 4). these differences are attributed to many factors as age, level of education, gender and this agree with Tatemichi et al., (1994) who emphasized that biases related to subject variables (age, education, sex and race) known to affect psychometric test performance independence of disease state. Also this agreed with the study of Saxena, (2006) who found that increasing age and lower education level is of significant correlates of post stroke cognitive impairment. He attributed that to the probability that with
increasing age there may be a concomitant degenerative process setting in and the lower education level may be associated with lesser mental reserve.

In the current study, effect of educational level on the scores of MMSE and Rehacom parameters was also examined revealing a very highly positive correlation regarding level of attention concentration and logical reasoning of GB while it was a non significant correlation in GA. The non significant correlation in group A may be appeared due to that cognitive impairment was severer in GA due to the factor that plays a great role in cognitive impairment, which is side of lesion. So, level of education didn't show a governing role in level of cognition due to the presence of lesion on the right hemisphere which has more devastating effect on cognition as what will be mentioned later. The non significance was also observed at the correlation of educational level with MMSE. The wide range of educational level affected the levels of the examined items of RehaCom and their reaction times.

The obtained results from the present study agree with a study done by Honjo et al., (2009) which emphasized that men and women with low level of education would be more likely to have cognitive limitations compared to these with high level of education. Also the study done in Ain Shams University by Sweed et al., (2009) indicated that less educated people were found to perform worse on mental status tests than those with more education.

In the study of Leibovivi et al., (1996) it was revealed that while education does play a significant role in the evolution of cognitive deficits, its impact varies greatly according to the age of the subject at the onset of the impairment and the type of cognitive function. The study suggested that level of education may have a more important impact on changes in secondary memory and language functioning, but that elsewhere age is the more important factor. The same study suggested that on cognitive functions such as attention, implicit memory and visuospatial analysis, level of education seems to make relatively little difference to the rate of change over time.

In MMSE, the education was found to be the most powerful independent factor affecting MMSE scores compared to age and gender and that's why all the illiterate patients were excluded from the present study. This come in agreement with the study of Sweed et al., (2009) which revealed that there was a highly significant positive correlation between number of educational years and the total mean of MMSE. Also they stated that those with low educational years have
12 times the risk of having lower MMSE scores compared to higher educational years, and many studies confirmed these results as well (Talaat et al., 2006 and Khedr et al., 2009).

Alstott et al., (2009) emphasized that lesions of specific brain regions are often associated with specific cognitive and behavioral disturbances and lesions of some areas tend to have more severe effects than others.

In the current study, it was found that cognitive impairment, especially at the level of attention concentration, is correlated more with lesions affecting the right hemisphere. Also, it was found that the level of attention concentration and logical reasoning are much lower in patients having strokes at the temporo-parietal and parietal regions especially in group A (Appendices 3 and 4). This result agree with many studies which emphasized that, patients with lesions in the temporo-parietal (T-P) region had the lowest mean cognitive tests including MMSE (Talaat et al., 2006 and Alstott et al., 2009).

Stein et al., (2009) also mentioned the major locations of the brain which allow single discrete infarctions to cause multi-domain cognitive impairment, among these strategic locations which are fed by the middle cerebral artery, are the angular gyrus and the temporo-parietal region.

The less severely cognitively impaired patients in the present study suffered usually from lesions affecting basal ganglia and thalamus, most of the time lacunar infarctions were found. This agrees with Neuropathological studies pointed to lacunar infarctions in regions such as the basal ganglia and thalamus which developed cognitive deviation (Vintes et al, 2000; Chui, 2007 and Thomann et al., 2008).

In the current study, it was found that lacunar infarcts that are present in critical locations as thalamus and internal capsule are associated with cognitive impairment in some patients especially in GA. This finding agreed with Selnes and Vinters, (2006) who stated that lacunar infarcts involving the thalamus, internal capsule and basal ganglia are sometimes associated with cognitive effects including confusion and memory impairment. This strongly agrees with many studies (Yao et al., 1992 and Tay et al., 2006). khedr et al., (2009) stated that large sized infarctions are expected to produce more cognitive impairment compared to small sized infarction unless the small infarctions are in strategic locations even when they are lacunar. This statement strongly agreed with Talaat et al., (2006) as well.
Despite the role of thalamus and basal ganglia in cognitive function, some patients in the current study with injury to thalamus and basal ganglia regions had a cognitive impairment that was not of sufficient severity to appear in the scores of MMSE but it showed abnormal cognitive level according to RehaCom that was near in score to low normal levels compared to the extremely low level in patients suffering from strokes in temporo-parietal territory.

Some patients with lesions that involve areas apparently not related to areas of cognition reported normal values in MMSE and normal levels of RehaCom but showed a reaction time that was higher than normal for RehaCom. So it was concluded that despite that stroke patients may show normal global cognitive function, there is still evidence of affection of specific domain of cognition in some way even if it only appears in reaction time. This is because the fact that cognitive function is not confined to specific areas of the brain, which there is no doubt that it plays a major role in cognition, but there are other connections in the brain that may not be related directly anatomically to the area of lesion but it affects in some degree the cognitive function. This fact was previously confirmed by the study of Alstott et al., (2009).

In the present study, there was a very highly significant difference (males) and significant difference (females) appeared in comparing right strokes with normal subjects in RehaCom attention concentration, and there was highly significant difference appeared in logical reasoning (males) when comparing right strokes with normal subjects as well. These results revealed how much the right stroke can be devastating when considering the matter of cognition compared to the left stroke. This also clearly appeared when right and left strokes were compared to each other and showed a highly significant difference mainly in males for attention concentration assessment. When correlations have been studied, it revealed a significant positive correlation between side of lesion and level of attention concentration of RehaCom assessment where unit increase is levels of attention and concentration led to a corresponding increase in the probability that the lesion is on the left side. While correlation between sides of lesion with MMSE didn't show significance as MMSE was not sensitive enough to show the differences between right and left hemispheric strokes.

The above results prove the major role of right hemisphere in cognitive function compared to left. This agree with the study of Stein et al., (2009) who reported that damage to the right as opposed to the left hemisphere is more likely to induce severe disabilities that reduce
independence, thus, rather than being the “non-dominant” hemisphere, the right hemisphere in many aspects appear to be the governing hemisphere.

The effect of left hemispheric stroke on cognitive function mainly represented in verbal and language abilities affection while the right hemispheric stroke mainly affected the visuospatial and attention functions. There are some shared cognitive functions between both hemispheres but as mentioned before the right non-dominant hemisphere showed the governing role. The asymmetry of both hemispheres in cognitive function that was founded in the current study agrees with Patel et al., (2002) and Berg et al., (2003). Johnson, (1998) also reported that the lesion in left hemisphere causing mainly impaired language or reduced speech intelligibility (dysarthria or apraxia) where communication usually remains intact with the potential to learn new information, while the right hemisphere lesions usually cause impaired cognitive processes including difficulty focusing attention & impulsivity, perceptual & temporal deficit, reduced visual memory skills, difficulty with problem solving and poor judgment.

Voos & Ribeiro, (2007) hypothesized that because the left hemisphere plays a larger role in motor behavior, patients with left hemispheric injuries would demonstrate greater initial deficits and slower recovery of the motor functions of gait and functional independence after injury. On the other hand, because the right hemisphere plays a larger role on spatial orientation and posture, patients with right hemispheric injuries would demonstrate greater deficits and slower recovery rates of the postural and spatial attention functions after injury. Also the author stated that beside severe language dysfunctions, patients with left hemispheric injuries tend to demonstrate a greater frequency of apraxias.

Voos & Ribeiro, (2007) also emphasized that motor activities that require planning are more related to the left hemisphere and are therefore more affected after left hemispheric injuries. And that the majority of activities of daily living involve complex motor sequences. It is possible to suppose that performance of these activities will be more affected in patients with left hemispheric injuries, especially because of the alterations in motor responses observed after CVA (hemiparesis). Therefore, part of the movement sequence would need to be reprogrammed for activities of daily living. The functional impact of injuries to the right hemisphere is also considerable, Patients with such injuries, initially demonstrate body image deficits, neglect of the extracorporeal space opposite to the side of the injury and visuomotor deficits. Hemi neglect and
the consequent lack of recognition of functional losses on the opposite side of the body could constitute a particularly important obstacle to functional recovery of patients with injuries in the right hemispheric. The lower demands for use of the non-dominant upper extremity in daily activities compared to the dominant upper extremity would be an additional factor to interfere with recovery. This would reduce the motivation of the patient to try to use the affected extremity, leading to its maintenance of neglect.

The study of Voos & Ribeiro, (2007) insured that the functional affection that was found in some of the patients with left strokes in the current study usually attributed primarily to the effect of motor decline following dominant hemisphere affection rather than cognitive dysfunction compared to right strokes. On the other side, some studies disagree with the fact that affection of right hemisphere cause cognitive affection that is more severe than left, among these studies is the study of Spaletta et al., (2003).

In the current study, despite the whole differences between right and left strokes, they share the same delayed reaction time during performing the RehaCom test and so there was no significant difference when comparing right and left stroke patients’ reaction time.

There was no significant difference between results of MMSE in right and left strokes despite the presence of highly significant difference in the attention concentration element of RehaCom. This lead to many results; First: the MMSE was not sensitive tool to predict the mild changes in cognitive function, and Second: that MMSE may be good for global cognitive function assessment but not for single cognitive element. These results are strongly agreed with many studies; Serper & Allen, (2002) and Blake et al., (2002) who stated that MMSE identifies individuals who have a high probability of moderate to severe global cognitive impairment, especially elderly patients. However, the MMSE also has important limitations as it is found to be less sensitive in the detection of milder forms of dementia and cognitive dysfunction among patients. Strauss et al., (2006) also confirmed that MMSE may miss a significant proportion of individuals who have mild memory or other cognitive losses. Further, Strauss et al., (2006) stated that the presence and nature of cognitive impairment should not be diagnosed on the basis of MMSE scores alone and that the examiner needs to follow up suspicions of impairment with a more in-depth evaluation. According to the previous studies, using another assessment tool for cognition with MMSE was a must, so, RehaCom was chosen to play that role.
There was a significant difference between right and left strokes regarding Barthel index with the best score is for group B (left stroke) despite it is the dominant side! This was also showed up when the correlation between cognition and function was studied in the current study. This confirms that the cognitive impairment may have much devastating effect than motor disability especially that patients were chosen to have hemiparesis with good muscle power that exclude the element of severe motor disability which may be caused by high degrees of spasticity. This finding agreed with Saxena, (2006) and Siti Amina et al., (2008).

The functional impact of cognitive impairment appears in both right and left strokes where positive correlations appeared between level of function and level of cognition. However, its presence in right stroke is more attributed to cognitive impairment and its impact on function is more complicated than does the left stroke. The effect of left stroke on function is usually attributed to motor and verbal dysfunction rather than cognitive decline. These findings agree with the study of Sunderland et al., (1999) who reported that visuospatial deficits were the major cause of dexterity errors after right but not left hemisphere damage, and that there is reduction in the accuracy of rapid reaching for targets due to mild visual neglect or spatial disorientation after right hemisphere damage.

An important point that has to be mentioned is that reaction time for somehow affected the performance of function but not for high degree, that appeared as non significant correlation between reaction time and Barthel Index. Beside, the mild affection detected by RehaCom didn’t have a strong affection on scores of Barthel Index (Appendix 3 and 4). This maybe will show affection when evaluation is done using Instrumented Activities of Daily Living (IADL) test that needs high performance of cognitive abilities. This is because the automatic nature of ADL may overcome the effect of mild cognitive impairment. These conclusions are in agreement with previous studies & researches; Goldenberg and Hagmann (1998) who reported that some apraxic patients were independent with ADL tasks despite evidence of cognitive impairment. Also Walker et al., (2004) reported that patients with cognitive impairment may be able to complete the functional tasks if given sufficient time. Therefore, it seems that routine manual tasks are robust in the face of cognitive deficit. Performance may be slow and detailed video analysis may show clumsiness, but the task is eventually completed successfully.
The positive correlations that were found between RehaCom and Barthel Index & MMSE and Barthl index indicate how much the cognitive impairment has a strong impact on functional abilities of stroke. This clearly appears in the significant positive correlation between MMSE & BI in right stroke compared to the non significant correlation of MMSE & BI in left stroke supported by the fact that right stroke has more severe cognitive impairment than left stroke as mentioned before. This conclusion is strongly supported by many authors (Tatemichi et al., 1994; Mercier et al., 2001; Walker et al., 2004; Dodge et al., 2005; Claesson et al., 2005; Mokashi, 2005; Saxena, 2006 and Siti Amina et al., 2008).

In the view of the previous data, it can be concluded that cognitive impairment has a definitive impact on the functional abilities of stroke patients especially those with lesions affecting the right hemisphere. Consequently, much attention should be directed to the assessment of cognitive functions during the planning of physical therapy programs for stroke patients so as to improve the functional outcome of these patients.

**SUMMARY AND CONCLUSION**

The present work was designed to investigate the impact of cognitive impairment on functional abilities of stroke patients. Thirty stroke patients from both sexes were selected to participate in this study. Patients were assigned into two groups: fifteen patients with right cerebrovascular accident [CVA] (group A), and fifteen patients with left CVA (group B). Age of the patients ranged from 45 to 60 and the duration of illness ranged from three to 18 months. Fifteen normal subjects (group C) were chosen matched in age with patients groups were also included as a control group.

The patients sample was selected from the Department of Neurology, Faculty of Medicine, Cairo University and from the outpatient clinic of the Faculty of Physical Therapy,
Cairo University. Evaluation was conducted at the cognition laboratory at Faculty Physical Therapy, Cairo University.

All patients (group A and B) were evaluated clinically and radiologically. Assessment of cognitive function was done using Mini Mental State Examination (MMSE) and RehaCom. Barthel Index (BI) was used to assess activities of daily living. While subjects of group C were evaluated with RehaCom. Evaluation by RehCom included the element of attention concentration with its maximum and minimum reaction times, and the element of Logical reasoning with its reaction time quarter one and three; While MMSE was used for general assessment of cognition.

The collected data were statistically analyzed. The results of RehaCom indicated that: There was a highly significant difference regarding levels of attention and concentration between patients of two groups A and B, whereas there was no significant difference regarding levels of logical reasoning between patients of two groups A and B. The results of MMSE indicated that: There was no significant difference between patients of two groups A and B. The results of BI indicated that: There was a significant difference between patients of two groups A and B with the higher significant score is for group B.

The values obtained from cognitive evaluation by both RehaCom and MMSE were correlated to the results of functional evaluation by BI. The results revealed that: when RehaCom parameters were correlated to BI, a significant positive correlation was detected between Barthel Index (BI) and levels of attention concentration, while a highly significant positive correlation between Barthel Index (BI) and levels of logical reasoning in group A was found. Besides, there was a non significant correlation between Barthel Index (BI) and maximum reaction time, while there was a non significant correlation between Barthel Index (BI) and minimum reaction time in group A. Also, a non significant correlation between Barthel Index (BI) and reaction time quarter 1 was found, while there was non significant correlation between Barthel Index (BI) and reaction time quarter 3 in group A as well.

There was a highly significant positive correlation between Barthel Index (BI) and levels of attention concentration, while a highly significant positive correlation between Barthel Index (BI) and levels of logical reasoning regarding group B was detected. Beside, a non significant correlation was detected between Barthel Index (BI) and maximum reaction time, while there
was a non significant correlation between Barthel Index (BI) and minimum reaction time in group B. Also, a non significant correlation between Barthel Index (BI) and reaction time quarter 1 was found, while there was a non significant correlation between Barthel Index (BI) and reaction time quarter 3 in group B as well. When MMSE correlated to BI; there was significant positive correlation between Barthel Index (BI) and Mini Mental State Examination (MMSE) regarding group A, while there was a non significant correlation between Barthel Index (BI) and Mini Mental State Examination (MMSE) regarding group B.

From the obtained results of this study, it is concluded that cognition is affected in stroke patients compared to normal subjects. Right hemispheric stroke is associated with more severe cognitive dysfunction compared to left hemispheric stroke. Consequently, functional disability is severer and more obvious in patients with right hemispheric stroke compared to patients with left hemispheric stroke. Beside, MMSE was not a sensitive tool for detection of mild cognitive affection in stroke patients.

Finally, cognitive impairment has a definite impact on functional abilities of stroke patients which vary in degree according to the severity of cognitive impairment. And that the severity of cognitive impairment is governed by the site of lesion and the side of hemispheric affection. So, much attention should be directed to this point during physical therapy training so as to improve the functional outcome of stroke patients.

**Recommendations**

In the light of the achieved results of this work, the following recommendations are suggested:

- Evaluation of cognitive functions on a larger Sample size including large number for both sexes.
- The same study could be done on wide age group.
- Studies needed using cognitive assessment tools rather than Mini Mental State Examination.
- Studies to correlate the level of cognition with site of hemispheric lesion or the type of stroke (haemorrhagic and ischemic)
- Application of the study on other disorders that may cause secondary neuropsychological complications (e.g. Diabetes Mellitus) rather than primary neurological disorders.
• Studying the effect of mild cognitive impairment on occupational and vocational abilities.
• Studying the training of cognitively impaired patients and its effect on functional recovery.
• Using of cognitive rehabilitation in chronic stroke patients.
• Studies are needed to evaluate cognitive functions using other elements of RehCom.
References


Electronic references