Assessment Protocol of Motor Programming Skills after Cerebrovascular Insults

Original Article

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ABSTRACT

Background: Stroke causes a greater range of disabilities than any other condition that affect the motor system, communication, urinary system and all other systems of the body.

Objective: Aim was to devise a holistic multidimensional battery for assessment of motor programming skills in patients with established cerebrovascular insults and correlate it with quality of life of those patients.

Patients and Methods: An analytical cross-sectional study carried out on 116 adults attended the phoniatric outpatient clinic in Kasr Al Aini and Benha university hospitals from October 2016 to July 2018divided into group 1 which included 58 post stroke adults experienced cerebrovascular insults of more than 6 months and group 2 included 58 normal adults as a control group. The two groups were subjected to the interview and personal history, modified comprehensive aphasia test, assessment protocol of some motor programming skills.

Results: There was a highly significant difference between both groups regarding sub-items and total score of limb apraxia except for pantomime intransitive sub-item. A significant difference regarding sub-items and total score of ideational apraxia, scores of all sub-items and total score of ideomotor apraxia, all sub-items and total score of verbal apraxia, sub-items and total score of buccofacial apraxia except for sub-item of soft palate and pharynx, all sub-items and total score of constructional apraxia, sub-items and total score of dressing apraxia and swallowing apraxiascore as shown in the observational checklist.

Conclusion: Apraxia is a common finding after cerebrovascular insults (CVI) which mainly presents with aphasia and/or dysarthria.

Key Words: Apraxia, buccofacial, cerebrovascularr insults, dressing, ideomotor, swallowing, verbal.

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INTRODUCTION

Every two seconds, someone in the world has a stroke, There were almost 17 million incidences of first-time stroke worldwide in 2010[1]. Communication may be impaired following cerebrovascular insults (stroke) as a result of disorders of motor control (dysarthria and dyspraxia) or language (dysphasia) or both. Aphasia, a term which is used interchangeably with dysphasia, is defined as an acquired impairment of the components of the language system (semantics, syntax, phonology, morphology and pragmatics). The language limitations include both expressive and receptive modalities (comprehension, speaking, reading and writing) to varying degrees[2].

Apraxia is a higher-order motor disorder impairing the ability to correctly perform skilled, purposive movements as the result of neurological disorders most commonly stroke, dementia and movement disorders. It is increasingly recognized that Apraxia negatively influences activities of daily living[3].

Acquired apraxia consists of various types of apraxia among them; limb apraxia, ideational and ide motorapraxias, buccofacial apraxia, dressing, constructional apraxia and acquired verbal apraxia[4].

Acquired apraxia of speech frequently co-occurs with dysarthria and/or aphasia in a correlation of 0.40% and sometimes with other types of apraxia. Acquired apraxia of speech does not involve muscle weakness, paralysis, spasticity, or involuntary movements typically associated with dysarthria, or language comprehension or production deficits that characterize aphasia[5].

Praxis means action which refers to the ability to perform complex learned motor actions in response to

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verbal command, imitation or pantomiming[6].

A holistic multidimensional assessment of the various motor programming skills had not been tailored yet in Egypt. Such an assessment will help diagnose underlying motor programming difficulties which have secondary effects on, speech, and swallowing. Consequently, this will shed light on various defects that has to be incorporated in the patient's remediation programs to achieve better functional outcomes.

The primary aim of this study was to devise a holistic multidimensional battery for assessment of motor programming skills in patients with cerebrovascular insults in an attempt to have a detailed clinical profile of their underlying difficulties and correlate it with quality of life of those patients and the secondary aim was to know the comorbidity of different types of apraxia together.

PATIENTS AND METHODS

This study is an analytical cross-sectional study that has been carried out on 116 adults aged more than 18 years after obtained an informed consent, who attended the phoniatric outpatient clinic in Kasr Al Aini and Benha university hospitals in the period from October 2016 to July 2018. The study has been approved by the institutional research ethics committee at October 2016 with unique protocol number of 1-150316 before experiment was started and that has been conducted in accordance with the principles set forth in the Helsinki Declaration.

They were divided into two groups used closed sealed envelope. Group 1 which includes 58 Egyptian post stroke adults and group 2 that includes 58 normal adults as a control group after obtaining an informed consent from all of them.

Patients were selected from adults who experienced cerebrovascular insults of more than 6 months duration to ensure full neurological stabilization of the condition with language and speech difficulties. The control group was selected from relatives of the patients with the same age group who had no history of cerebrovascular insults (CVI).

The exclusion criteria included; the presence of other central neurological lesions or dementia before the current stroke, addiction, presence of severe physical weaknesses, severe aphasia and patients in the first 6 months of the cerebrovascular insult.

The two groups under the study were subjected to the following protocol of assessment that includes:Interview and personal history taking including name, age, sex, marital status, handiness, literacy level and occupation. Then Modified comprehensive aphasia test was carried out to assess the receptive and expressive language abilities[7]. It consists of 34 subtests divided into three parts: the cognitive screen, the Language Battery, and the Disability Questionnaire. Questionnaire of quality of life of the patients under study that was specifically designed,and it includes 26 questions to evaluate the impact of the CVI on the patient's self-care, social life, psychiatric health, ability to work and specific daily life activities. Appendix (1).

Then an assessment protocol of motor programming skills that was specifically designed in the current study and included the following:The applied test was carried out first on randomly chosen 10 adult patients as a pilot study to check clarity and suitability of the materials used. Based on this pilot study, modifications to some tests were done and the average administration time of the assessment was determined which is 45 minutes done in one setting.

The assessment protocol of motor programming aimed at assessing several types of apraxia that might present post CVI as limb apraxia, verbal apraxia, buccofacial apraxia, ideational and ideomotor apraxias, constructional, dressing and swallowing apraxias. During the assessment, the patient was put under several challenges such as doing the action spontaneously, on imitation and on command, and to perform unpurposful and purposeful tasks. The purposeful tasks were divided into transitive (tool related) and intransitive (communicative) tasks that might help to induce apraxic errors. The different types of apraxia were assessed as follows: Assessment of limb apraxia:The test idea test was taken froma previous study done by Vanbellingen *et al.*[8]. It was divided into two parts:The receptive part during which the patient was asked to explain the purpose of the gesture or explains verbally what the assessor is doing.The expressivepart: which assessed the ability of the patient to perform a gesture either by imitation or pantomiming (after giving the orders verbally to the patient). The patient was asked to use the functioning hand either the dominant or the non-dominant. The gestures included were divided into meaningless such as "Put your thumb on your nose", intransitive (communicative) such as "Use scissors in the absence of the tool itself" and transitive (tool related) such as "drink from a cup".

Scoring: the receptivepart was scored on 5 points scale as follows: 5 points score when the patient produced a quick verbal response upon the gesture performed.4 points score when the patient responded incorrectly but could auto- correct him/ her in a short time.3 points score if the patient auto-corrected himself / herself in a long time.2 points score when the patient responded correctly after a demonstration. 1-point score when the patient responded incorrectly despite the demonstration.0-point score when there was no response.

The expressive part was scored also on 5 points scale as follows:5 points score when the patient could perform an accurate rapid, complete gesture.4 points score when the patient produced an incorrect gesture but could correct him/ herself.3 points score: when the gesture was defective in speed, amplitude, or accuracy.2 points score when a prompt was introduced.1-point score when the gesture was defective in speed, amplitude, or accuracy after a demonstration. 0-point score when the patient couldn't

perform a gesture.After the scores of the two sections were calculated, the total score (out of 110) was calculated by adding the scores of the two sections.

Assessment of verbal apraxia:The idea of this test was taken from apraxia battery for adults (second edition) (ABA-2) by Dabul[9]. This part was designed to assess the verbal abilities of the patient to demonstrate whether there are apraxic errors of speech following the CVI or not. The section constitutes of several subtests which include: diadochokinesis: which comprises of two items: the rate and accuracy with increasing speed. Rate: which assesses the ability of the patient to repeat certain sounds in a given time and it consists of two groups; the first one is repeating the isolated syllables: /ba/ then /ta/ then /ka/ as /pa/ is not in the Arabic speech sounds. the number of errors was calculated in 30 seconds.

Scoring: the scores were put on 6 points scalefrom 6 points score if the number of errors was 0-9 to 0-point score if there was no response given by the patient.The second group is repeating the alternating syllables: /ba/ / ta/ /ka/once at a time and measuring the number of errors in 30 seconds.

Scoring: the scores were put on 4 points scale as follow from 4 points score if the number of errors was 0-4, to 0-point score: if there was no response given by the patient.

Accuracy with increasing speed: is scored as follows:4 points score if the patient performed the diadokinetic rate task fast and accurate.3 points score if fast but not accurate. 2 points score If slow and accurate.1-point score if slow and not accurate.0-point score if the patient couldn't repeat any of the sounds.

The ability to repeat words: this measure the ability of the patient to repeat 6 words (divided into three groups with 2 words in each group) told by the assessor. These words are graded in difficulty from monosyllabic to tri and tetrasyllabic words. The patient was given three trials for each word to see if his/ her production got better or not.

Scoring:1-point score if the patient was able to repeat the word. 0-point score: if not.After that the total score was calculated and was equal to 6.

The ability to repeat words of increasing length was assessed by asking the patient to repeat 2 series of words increasing in length. In each series, there was three words. Scoring: 2 points score if the productionwas correct. 1-point score if the patient produced rephrasing with self-correcting, delays, or articulatory errors.0-point score if there was no response.

Latency time: it measures the time taken by the patient to name familiar objects or pictures like scissors and a cup; 6 familiar pictures were used. The time for naming is measured by a stop watch.Scoring:2 points score when the patient produced a prompt response with no delay.1 point score when the patient produced a late response which is more than 0.5 seconds.0 point score: if there was no response.Then the total score was calculated by summation of the scores of the six pictures. Total score was equal to 12.

Inventory: this subtest consists of 4 sub items:spontaneous speech: in which the patient was asked to talk in 3 minutes about his history of illness then the number of errors, as regards structure of the sentences and presence of meaningless words was measured.

In Picture description, the patient was asked to describe a picture which is specifically drawn in the current study by a specialized artist. Scoring: 3 points score if the description was correct regarding the relevance to the content of the picture and the structure of the sentences, the patient should utter at least two correct sentences with intact sentence structure without using of any psuedowords. 2-points score if the description was correct but with help in the form of asking the patient leading questions such as (look here, what happens here, what else) or if the patient gave a correct description with errors. 1-point score if the description was wrong. 0 point score would be earned, if the patient couldn't describe or give any correct response.

Reading: the patient was asked to read a chosen short paragraph and was assessed as regard time taken by the patient in reading and the number of articulatory errors produced during reading.Scoring: the patient earned a score on 3 points scalescale:2 points score was earned if the patient could read in optimum time (average 75: 90 seconds).1 point score was earned if the patient could read but in more than 90 seconds. 0-point score was earned if the patient was not able to read This part of the assessment wasn't done for illiterates.

Automatic speech: the patient was asked to count from 1 to 20 in both forward and backward manners and the number of errors was calculated. No help or feedback was given to the patient.Scoring: the scores were put on a 3-point scale from3 points score if the number of errors was 0-14 to 0 point score if no response was given by the patient.

Assessment of buccofacial apraxia: this part was done to assess the non-speech non-swallowing oral motor function including the functions of lips, face, tongue, jaw, soft palate and pharynx. Each part was tested in three conditions: at rest, imitation and in passive manner. An oral motor checklist was used. Scoring: 1-point score when the patient could perform the action. 0-point score when the patient couldn't perform actions. The total score was calculated by summation of the items. Total score was equal to 46. Appendix (2).

Assessment of ideational apraxia: The idea of this test was taken from Zwinkel's *et al.*[10]. This part assesses the ability of the patientto extract the idea of performance from the task. In the assessment, the patient was exposed to three sets of objects which were presented to the patient

with the same instruction: 'Show me how you would use'. Each set contained three objects used in daily activities: the first set included (key, pen and cup) which presented only by verbal request, without the real presence of the object. The second set included (comb, hammer and fork) and presented visually, with the presence of the real object but the patient wasn't going to use them.The third set included (sharpener, buckle and screwdriver) which would be used by the patient.Scoring for each set:3 points score when the patient did the action correctly. 2 points score when the action was done correctly after repeated trials. 1-point score when the patient did the action helped by verbal prompt.0-point score when the action was done incorrectly.The total score of each set was calculated out of 9. The total score of the section was calculated by the summation of the total score of the three sets and was equal to 27.

Assessment of ideomotor apraxia: The idea of the test was taken from Vanbellingen and Bohlhalter.[3]

This part was used to assess the patient's ability to translate the idea into a motor act and was divided into two parts: The first part consists of five gestures in which the patient was asked to imitate immediately theassessor. For example: raising one's hand. Scoring for each: 2 points score when the patient could imitate the action correctly. 1-point score when the patient could imitate the action correctly but slowly or after repeated trials. 0-point score when the patient couldn't imitate the action by assessor. The total score of the sub- items was calculated by the summation of the scores of the items and was equal to 10.

The second part is multiple object use where the patient was asked to operate; two objects, e.g: a torch. Scoring: 2 points score when the multi task was fast and accurate. 1-point score when he performed it in a longer time more than 1 minute. 0 point score when he wasn't able to perform the task. The total score of this part was calculated by the summation of the 2 tasks and was equal to 4. The total scores of the two parts were summated together to give the total score of the section and was equal to 14.

Assessment of constructional apraxia: the patient was asked to assemble two shapes. The first one was a simple square and the second is a more complex one which was a square with diagonals. The assembly was done using matches. Scoring: 3 points score when the patient did the task correctly from the first trial. 2 points score if the task was done correctly after repeated trials. 1-point score if any prompt was introduced and 0-point score if the patient couldn't perform the task. The total score for the section was calculated and was equal to 6 by the summation of the scores of the simple and complex drawings.

Assessment of dressing apraxia: the patient was asked to dress him/ her shirt or a jacket. Scoring: 3 points score if the patient dressed himself/ herself correctly from the first trial. 2 points score if the patient did it correctly after repeated trials. 1-point score if a physical or verbal prompt was introduced and 0-point score if the patient couldn't dress himself.

Assessment of swallowing apraxia:tested by bed side assessment. The bed side assessment included 2 parts: the first part was the dry assessment and the second part was meal eating and self-feeding. Part 1 was done through an observational checklist which included 7 items: the patient has normal posture, the ability to control his own secretions and didn't show drooling, the ability to chew, ingested food smoothly, had completed oral evacuation, clearing of the oral cavity post swallow, the patient was safe and had no signs of aspiration such as cough and gurgely voice after swallow and the patient had normal tongue movement with no searching movement.Scoring:1-point score if the patient could achieve each item of the observational checklist. 0 point score: if the patient couldn't achieve. The total score of this part was equal to 7.

Part 2 consisted of introducing the three different food consistencies which are the fluids, semisolidsand solids. Each consistency was tested spontaneously, with elicitation and upon imitation. Scoring: 3 points score if the patient did the task spontaneously. 2 points score if the task was done with elicitation.1 point scores if the task was done upon imitation. The total score was calculated by the summation of the scores of the items and was equal to 9.

Statistical Methods

Data management and statistical analysis were done using SPSS vs. 25. Numerical data were summarized using means and standard deviations or medians and ranges. Categorical data was summarized as numbers and percentages. All apraxia scores were compared between two groups using Mann Whitney U test. Age was compared using Independent t test. Categorical data was compared using Chi-square test. Spontaneous and imitation tasks were compared using Wilcoxon signed rank test.

ROC analysis was done for each total score of different types of apraxia. Area under Curve (AUC) with 95% confidence interval and diagnostic indices including sensitivity and specificity were calculated for each. The values above 50% were considered sensitive and specific. Spearman correlations were done. “r” is the correlation coefficient.it ranges from -1 to +1. -1 indicates strong negative correlation, +1 indicates strong positive correlation while 0 indicates no correlation. Cronbach‟s alpha -as a measure of internal consistency- was calculated for the test. Cronbach‟s alpha above 0.7 indicates satisfactory internal consistency. All *P* values were two sided. *P* values less than 0.05 were considered significant.

RESULTS

One hundred and twenty posts rock patients were assessed for eligibility, 4 cases not meet inclusion criteria and excluded from the study and 116 were randomly

allocated to two groups (Figure 1). The current study was conducted on 58 Egyptian post stroke adults and 58 normal adults as a control group. The males constitute 55.2% while females constitute 44.8% of normal subjects. In post CVI patients, males constitute 65.5% while females constitute 34.5%. The lesion was left sided in 89.7% of postCVI cases while 6.9% were right sided and the lesion was bilateral in3.4% of cases.48.3% of the cases had mainly expressive aphasia while 46.6% had dysarthria and 5.2% of cases had bothexpressive aphasia and dysarthria.

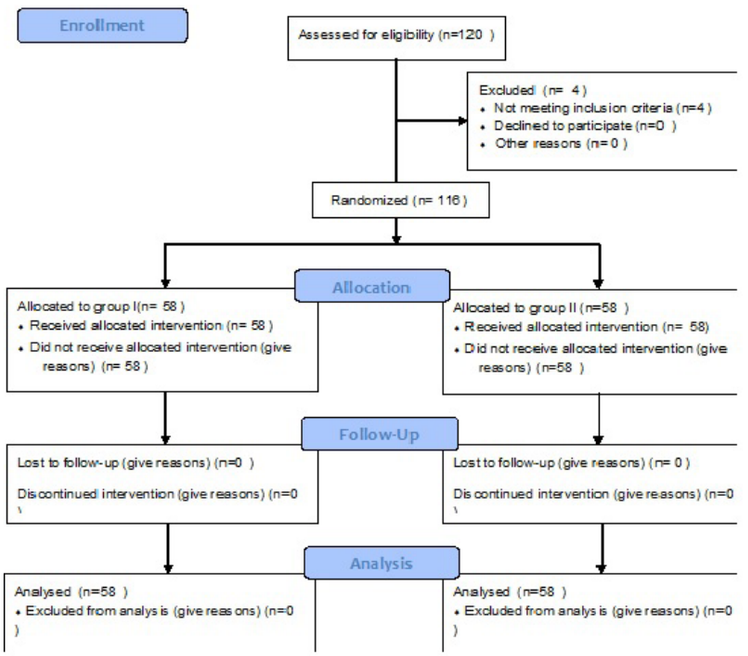

Fig. 1: CONSORT flow chart

Table 1 showed that there was a highly significant difference between cases and controls regarding scores of subitems and total score of limb apraxia except for pantomime intransitive subitem which showed non-significant difference.

Table 2 showed that there was a highly significant difference between cases and controls regarding scores of subitems and total score of ideational apraxia.

Table 3 showed that there was a highly significant difference between cases and controls regarding scores of all subitems and total score of ideomotor apraxia.

Table 4 showed that there was a highly significant difference between cases and controls regarding scores of all sub-items and total score of verbal apraxia.

Table 5 showed that there was a highly significant difference between cases and controls regarding scores of sub-items and total score of buccofacial apraxia except for sub-item of soft palate and pharynx.

Table 6 showed that there was a highly significant difference between cases and controls regarding scores of all sub-items and total score of constructional apraxia.

Table 7 showed that there was a highly significant difference between cases and controls regarding scores of sub-items and total score of dressing apraxia.

Table 8 showed that there was significant difference between cases and controls regarding scores of swallowing apraxia in the observational checklist only while scores of food consistencies showed no significant differences.

Table 9 showed that all items of the quality of life questionnaire were affected by the lesion.

Table 10 showed that verbal apraxia constitutes thehighest percentages among cases while constructional apraxia constitutesthe lowest percentage.

Table 11 showed that 82.8% of cases had combinedapraxia and 17.2% had only single type of apraxia.

Table 12 demonstrated that the most frequent combination was of verbal apraxia and buccofacial apraxia whichconstitutes 41.67%. Table 13 demonstrated that verbal apraxia andbuccofacial apraxia were the only types which presented isolated by 8.6% and 6.9% respectively.

Table 1: Comparison between cases and controls regarding scores of subitems and total score of limb apraxia.

	Cases		Mode	Controls		Mode	
Subtest	Median	Range		Median	Range		*P* value
Receptive	25	(0 - 25)	25	25	(25 – 25)	25	<0.001**
Imitation meaningless	15	(6 - 15)	15	15	(15 – 15)	15	0.002**
Imitation intransitive	15	(6 - 15)	15	15	(15 – 15)	15	0.001**
Imitation transitive	15	(6 - 15)	15	15	(15 – 15)	15	0.023**
Pantomime meaningless	15	(0 - 15)	15	15	(15 – 15)	15	0.002**
Pantomime intransitive	10	(3 - 15)	10	10	(10 – 10)	10	0.77
Pantomime transitive	15	(9 - 15)	15	15	(15 – 15)	15	0.001**
Total	110	(50 - 110)	110	110	(110 - 110)	110	<0.001**

**denote highly significant (*P*<0.001), * denote significant (*P*<0.05)

Table 2: Comparison between cases and controls regarding scores of subitems and total score of ideational apraxia

	Cases (n= 58)		Mode	Controls (n = 58)		Mode	
Subtest	Median	Range		Median	Range		*P* value
Gesturing	9	(0 - 9)	9	9	(9 -9)	9	0.002**
Verbal description	9	(0 - 9)	9	9	(9 - 9)	9	<0.001**
Tool use	9	(0 - 9)	9	9	(9 - 9)	9	0.081*
Total	27	(0 - 27)	27	27	(27 - 27)	27	<0.001**

**denote highly significant (*P*<0.001), * denote significant (*P*<0.05)

Table 3: Comparison between cases and controls regarding scores of subitems and total score of ideomotor apraxia.

	Cases (n= 58)		Mode	Controls (n = 58)		Mode	
Subtest	Median	Range		Median	Range		P value
Isolated sounds	6	(0 - 6)	6	6	(6 - 6)	6	0.023*
Alternating sounds	4	(0 - 4)	4	4	(4 - 4)	4	<0.001**
Accuracy with increasing speed	2	(0 - 4)	2	4	(4 - 4)	4	<0.001**
Repetition	6	(0 - 6)	6	6	(6 -6)	6	<0.001**
Latency time	6	(0 - 12)	6	12	(12 - 12)	12	<0.001**
Increasing word length	4	(0 - 4)	4	4	(4 - 4)	4	<0.001**
Spontaneous speech	2	(0 - 3)	2	3	(3 - 3)	3	<0.001**
Picture description	2	(0 - 3)	2	3	(3 - 3)	3	<0.001**
Reading	1	(0 - 2)	1	2	(2 - 2)	2	<0.001**
Automatic speech	3	(0 - 3)	3	3	(3 - 3)	3	<0.001**
Total	36	(10 - 47)	36	47	(47 - 47)	47	<0.001**

**denote highly significant (*P*<0.001), * denote significant (*P*<0.05)

Table 4: Comparison between cases and controls regarding scores of subitems and total score of verbal apraxia.

Subtest		Cases (n= 58)		Mode	Controls (n = 58)		Mode	*P* value
		Median	Range		Median	Range		
Face	Rest	1	(0 - 1)	1	1	(1 - 1)	1	0.317
	Imitation	1	(0 - 2)	1	2	(2 - 2)	2	<0.001**
	PROM	1	(0 - 1)	1	1	(1 - 1)	1	<0.001**
Lips	Rest	2	(2 – 3)	2	2	(2 - 2)	2	0.023*
	Imitation	7	(4 - 7)	7	7	(7 - 7)	7	<0.001**
Jaw	Rest	3	(2 - 5)	3	3	(3 - 3)	3	<0.001**
	Imitation	3	(1 - 4)	3	5	(5 - 5)	5	<0.001**
Soft palate and pharynx	Rest	3	(1 - 3)	3	3	(2 - 3)	3	0.163
	Imitation	2	(2 - 2)	2	2	(2 - 2)	2	1
Tongue	Rest	3	(3 - 4)	3	3	(3 - 3)	3	<0.001**
	Imitation	8	(3 - 10)	8	9	(9 - 9)	8	<0.001**
	PROM	3	(2 - 8)	3	4	(4 - 4)	3	<0.001**
Total		38	(31 - 43)	38	42	(41 - 42)	38	<0.001**

**denote highly significant (P<0.001), * denote significant (P<0.05)

Table 5: Comparison between cases and controls regarding scores of subitems and total score of buccofacial apraxia.

Subtest		Cases (n= 58)		Mode	Controls (n = 58)		Mode	*P* value
		Median	Range		Median	Range		
Face	Rest	1	(0 - 1)	1	1	(1 - 1)	1	0.317
	Imitation	1	(0 - 2)	1	2	(2 - 2)	2	<0.001**
	PROM	1	(0 - 1)	1	1	(1 - 1)	1	<0.001**
Lips	Rest	2	(2 – 3)	2	2	(2 - 2)	2	0.023*
	Imitation	7	(4 - 7)	7	7	(7 - 7)	7	<0.001**
Jaw	Rest	3	(2 - 5)	3	3	(3 - 3)	3	<0.001**
	Imitation	3	(1 - 4)	3	5	(5 - 5)	5	<0.001**
Soft palate and pharynx	Rest	3	(1 - 3)	3	3	(2 - 3)	3	0.163
	Imitation	2	(2 - 2)	2	2	(2 - 2)	2	1
Tongue	Rest	3	(3 - 4)	3	3	(3 - 3)	3	<0.001**
	Imitation	8	(3 - 10)	8	9	(9 - 9)	8	<0.001**
	PROM	3	(2 - 8)	3	4	(4 - 4)	3	<0.001**
Total		38	(31 - 43)	38	42	(41 - 42)	38	<0.001**

**denote highly significant (P<0.001), * denote significant (P<0.05)

Table 6: Comparison between cases and controls regarding scores of subitems and total score of constructional apraxia.

	Cases (n= 58)		Mode	Controls (n = 58)		Mode	
Subtest	Median	Range		Median	Range		*P* value
Simple shape	3	(0 - 3)	3	3	(3 - 3)	3	0.001*
Complex shape	3	(0 - 3)	3	3	(3 - 3)	3	<0.001**
Total	6	(0 - 3)	6	6	(6 - 6)	6	<0.001**

**denote highly significant (*P*<0.001), * denote significant (*P*<0.05)

Table 7: Comparison between cases and controls regarding scores of subitems and total score of dressing apraxia.

	Cases (n= 58)		Mode	Controls (n = 58)		Mode	
Subtest	Median	Range		Median	Range		*P* value
Dressing apraxia	6	(0 - 6)	6	6	(6 - 6)	6	<0.001**

**denote highly significant (p<0.001)

Table 8: Comparison between cases and controls regarding scores of subitems and total score of swallowing apraxia.

	Cases (n= 58)		Mode	Controls (n = 58)		Mode	
Subtest	Median	Range		Median	Range		P value
Observational checklist	7	(4 - 7)	7	7	(7 - 7)	7	<0.001**
Fluids	3	(1 - 3)	3	3	(3 - 3)	3	0.317
Semisolids	3	(1 - 3)	3	3	(3 -3)	3	0.317
Solids	3	(1 - 3)	3	3	(3 - 3)	3	0.317
Total	9	(3 - 9)	9	9	(9 - 9)	9	0.317

**denote highly significant (*P*<0.001)

Table 9: Quality of life questionnaire subitems in the group of cases.

	Median	Range	Mode
Self-caring	4	(0 - 5)	4
Social life	2	(0 - 5)	2
Psychiatric problems	0	(0 - 2)	0
Work	3	(0 - 4)	3
Daily life activities	4	(0 - 5)	4
Total	11	(6 - 15)	11

Table 10: Distribution of different types of apraxia among cases.

		Cases (n = 58)	
		N	%
Verbal apraxia	≤46	54	93.1
No verbal apraxia	>46	4	6.9
ideational apraxia	≤24	23	39.7
No ideational apraxia	>24	35	60.3
Constructional apraxia	≤4	13	22.4
No constructional apraxia	>4	45	77.6
limb apraxia	≤104	26	44.8
No limb apraxia	>104	32	55.2
Bucco-facial apraxia	≤40	45	77.6
No bucco-facial apraxia	>40	13	22.4

Table 11: Distribution of combined and single types of apraxia in the group of cases.

		N	%
Apraxia	Combined	48	82.8
	Single type	10	17.2

Table 12: Demonstration of combined types of apraxia among cases.

Combination	N	%
Verbal and Bucco-facial	20	41.67
All types	9	18.75
Verbal, Ideational, Limb and Bucco-facial	8	16.67
Verbal, Ideational and Limb	4	8.33
Verbal and Limb	2	4.17
Verbal, Ideational, Constructional and Limb	1	2.08
Verbal,Ideational, Constructional and Bucco-facial	1	2.08
Verbal, Constructional, Limb and Bucco-facial	1	2.08
Verbal, Constructional and Bucco-facial	1	2.08
Verbal, limb and Bucco-facial	1	2.08

Table 13: Demonstration of single types of apraxia among cases

Types of apraxia	N	%
Verbal	6	8.6
Buccofacial	4	6.9

Figure 2 showed that the total limb apraxia had accuracy of 72.4% in discrimination between cases and controls. Best cut-off point for discrimination was 104 at which sensitivity and specificity were 44.8% and 100% respectively.

Figure 3 showed that the total verbal apraxia had accuracy of 96% in discrimination between cases and controls. Best cut-off point for discrimination was 46 at which sensitivity and specificity were 93% and 100% respectively.

Figure 4 shows that the total bucco-facial apraxia had accuracy of 85.6% in discrimination between cases and controls. Best cut-off point for discrimination was 40 at which sensitivity and specificity were 77.6% and 100% respectively.

Figure 5 showed that the total ideational apraxia had accuracy of 69.8% in discrimination between cases and controls. Best cut-off point for discrimination was 24 at which sensitivity and specificity were 39.7% and 100% respectively.

Figure 6 showed that the total ideomotor apraxia had accuracy of 59.5% in discrimination between cases and controls. Best cut-off point for discrimination was 12 at which sensitivity and specificity were 19% and 100% respectively.

Figure 7 showed thatthe total constructional apraxia had accuracy of 61.2% in discrimination between cases and controls. Best cut-off point for discrimination was 4 at which sensitivity and specificity were 22.4% and 100% respectively.

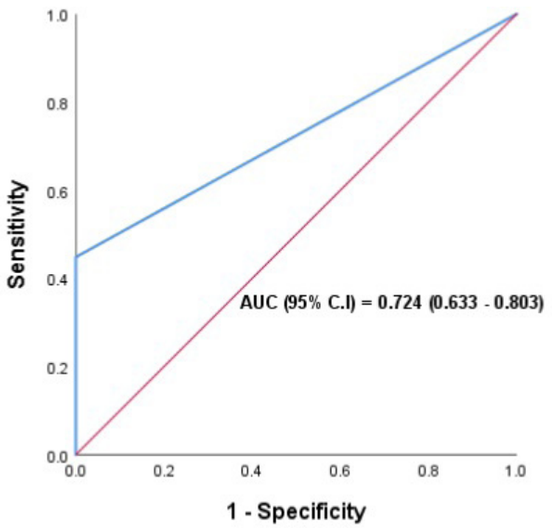

Fig. 2: ROC analysis for limb apraxia

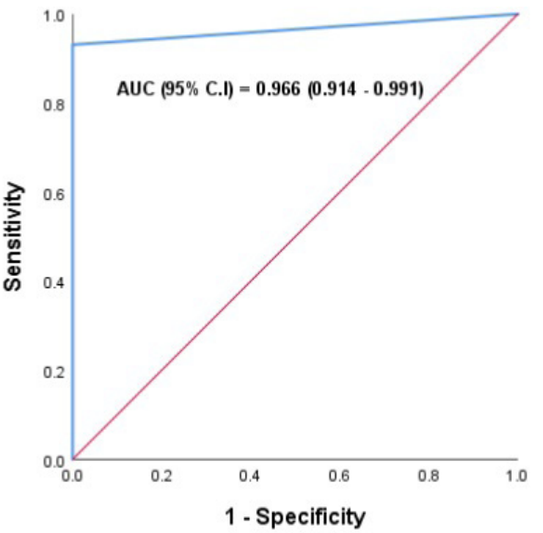

Fig. 3: ROC analysis for verbal apraxia

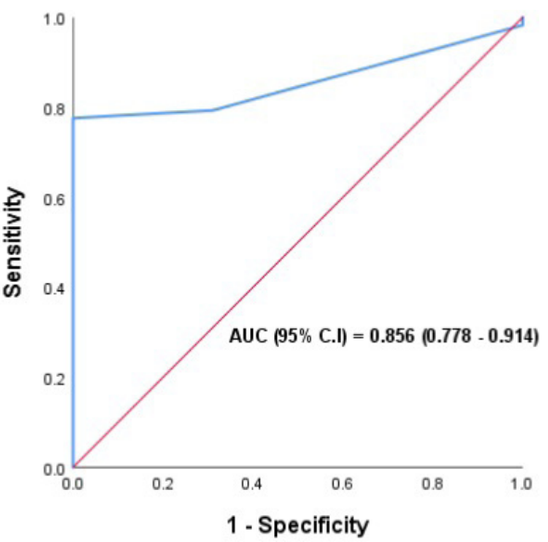

Fig. 4: ROC analysis for bucco-facial apraxia

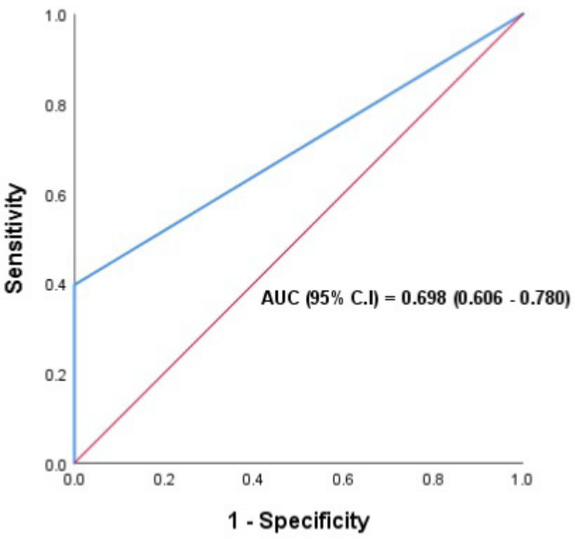

Fig. 5: ROC analysis for ideational apraxia

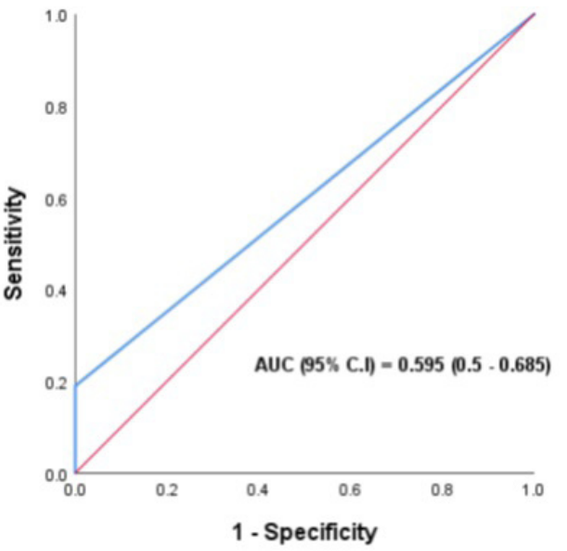

Fig. 6: ROC analysis for ideomotor apraxia

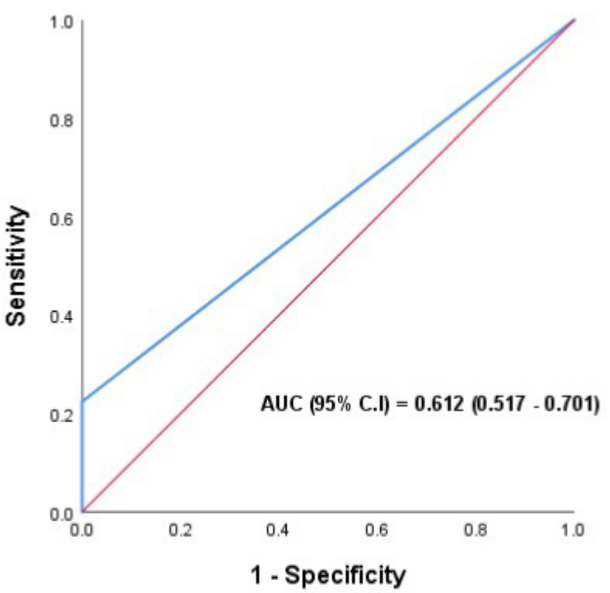

Fig. 7: ROC analysis for constructional apraxia

DISCUSSION

Apraxia is one of the common squeal after CVI; however, there is no established assessment for post CVI apraxia in Egypt because of the combined nature of the apraxia, as well as combined co-existence with aphasia and/or dysarthria. This raised the concern to design an assessment protocol to pick up cases with motor programming deficit that might render recovery and progress of aphasic patients slower. Designing of such an assessment tool will help in putting hands on areas of strength and weakness that will likely help in tailoring rehabilitation programs[3].

In this study, it was found that CVI is more common in left sided lesion and this can be explained by the fact of hemodynamic differences between the rights and left carotid artery circulations. This is primarily attributable to differences in the intima-media complex and flow velocity in the left carotid artery resulting in higher stress and intimal damage therein. This may induce atherosclerotic changes, leading to more severe left hemispheric ischemic events[11].

The current study shows a highly significant difference between cases and controls regarding scores of sub-items and total scores of limb apraxia, verbal apraxia, ideational apraxia, ideomotor apraxia, constructional apraxia and dressing apraxia. That can be explained by the presence of motor programming deficits and lack of motoric co-ordination in cases than controls.

Limb apraxia (LA) is a subtype of apraxia covering a wide spectrum of higher motor disorders caused by acquired brain disease or injury and affecting the performance of skilled learned movements carried out by the upper limbs[12].

In order to perform (execute) an action by the upper limb (like tool use), the program is planned in giving orders to muscles to move in certain sequencing and in certain timing. So, the tool use requires intact planning, programming, grasping and execution with or without the presence of the tool which is defective in cases more than controls.

The explanation by Vanbellingen *et al*., is that there is loss of hand and finger dexterity resulting from inability to connect and isolate individual innervations[3].

Also, Randerath *et al.*, have found that left brain damage patients show impairment in the grasping movements during single tool use. In comparison to healthy age-matched controls, patientsdemonstrated significantly higher percentage of non-functional grasps of the tools‟ handles. The impaired grasp was predominately followed by erratic demonstration of the tool use. In the real life scenario, those spatiotemporal deficits might result in mishandling of the object, leading to safety hazards, or frustration[13].

The result of this studyshows that the most affected items were repetition of alternating sounds, naming objects. The errors were presented in the form of delayed time of recall and inconsistency in the nature of errors, in addition to difficulty with picture description, spontaneous speech and speech on verbal command. This can be explained by that, these items need more co-ordination between the oral cavity musculature and other non-oral facial muscles which are affected in apraxia and motor programming deficits.

During the current study, it is observed that automatic speech was better than spontaneous speech. This could be attributed to that the programming of already saved plans is much easier.Also, spontaneous speech needs much more complex executive functions than automatic speech. It entails the co-ordination between working memory "visual and auditory", decoding, comprehension, encoding, programming and expression.

The findings of this study agree with Aboras *et al*., which showed that apraxic patients had obtained more errors in spontaneous speech than automatic speech[14].

Orofacial, or buccofacial apraxia (OFA) is characterized by a loss of voluntary control of facial, lingual, pharyngeal and masticatory muscles in the presence of preserved reflexive and automatic functions of the same muscles[15].

The typical patient fails to produce the correct movement in response to a verbal command or to imitate correctly a movement performed by the examiner. For example, the patient is unable to blink (open and/or close) their eyes, smile, open and close the mouth, protrude the tongue, speak or swallow voluntarily, but they can be observed to smile if something interesting happens and opening the mouth automatically during yawning[15].

The result of this study reveals that constructional apraxia is shown in simple and complex shapes because it requires more co-ordination between eye and hand movements to perform the task that increases with increasing the complexity of the required task.

Another explanation given by Russell *et al.*, thatapraxic errors increased with more complexity of the figure required to assemble because there was failure to re-map spatial information correctly when it is needed to move their eyes because this requires co-ordination between eye movement and hand movement[16].

The study shows highly significant difference between cases and controls regarding scores of sub-items and total score of dressing apraxia because the patients had difficulty to spatially orient a body to an article of clothing. Another explanation given by Fitzgerald *et al.*, is that the key deficit in dressing apraxia is related to general deficits in planning of gestures in both limbs[17].

The act of dressing itself is a very complex act and one of the later earned acts in early childhood. It requires a certain degree of balance, proprioception, fine and

gross motor control. This makes it most affected if higher functions are affected.

The results of swallowing apraxia can be explained by the fact that swallowing is a cascade of events that needs delicate co-ordination of tongue, jaw, lips and other musculature in addition to intact timing and protection, so failure to perform the action means deficits as regards the temporal and spatial aspects which is in agreement with Robbins *et al.*[18].

The results of this study agree with Daniels *et al.*, who identified a high occurrence of both oral and pharyngeal dysphagia in acute stroke patients[19].

This high prevalence of apraxia among study population emphasizes the fact that apraxia shouldn't be forgotten in evaluation and while designing the rehabilitation program as it has delirious effects on QOL of patients particularly when it presents in combined form.

The assessment of quality of life (QOL) after stroke is becoming important. Among our cases, all items of the quality of life questionnaire were significantly below normal. This can be explained by that the CVI had a negative impact on the daily life aspects of the cases. The most affected aspects are self-caring and daily life activities then work, followed by social life. This is in agreement with previous studies such as Crichton *et al.*[20], López-Espuela *et al.*[21] and Mandić *et al.*[22] who have shown that many stroke survivors experience a decline in their QOL in terms of impaired physical, functional, psychological, and social health.

In the current study, verbal apraxia constitutes the highest percentages (93.1%) among cases while constructional apraxia constitutes the lowest percentage (22.4%). 82.8% of cases had combined apraxia and 17.2% had only single type of apraxia.

In the current study, the most frequent combination is (the combination between verbal apraxia and buccofacial apraxia) as they share the same muscles and it constitutes 41.67% of cases. Verbal apraxia and buccofacial apraxia were the only types which presented isolated by 8.6% and 6.9%, respectively.

Many studies reported various combinations such as Ozsancak *et al*. who found that orofacial apraxia frequently coexists with limb apraxia. However, orofacial and limb apraxia can be dissociated, suggesting that the neural systems underlying these disorders are at least partially separable[23].

Vanbellingen *et al*.shows that ideational and ideomotor apraxia usually co-exists with limb apraxia because of the same parietal representation[3].

Fitzgerald *et al*. report that dressing apraxia sometimes co-exists with constructional apraxia because of the same representation[17].

Sever oral and verbal apraxias co-exist with swallowing apraxia because there is lack of labial, lingual and mandibular co-ordination in the oral stage with residual pooling of material on the tongue and palate, also the patients with swallowing apraxia don't lose weight because they eat well spontaneously (without verbal command) as in all types of apraxia and this explains why the spontaneous food intake had the best scores in the study Robbins[18].

The test designed in the current study is proven to be sensitive and specific. Sensitivity of the study ranges from 19% to 93% while specificity is 100% for all apraxia types.

In the literature, few tests provide their sensitivity and specificity such as Aboras *et al.*[14], Vanbellingen *et al.*[3] provided a number of assessments for limb apraxia showed cut-off point of 9 and 5 which differs from the current study because of the different scoring system and showed sensitivity and specificity of 88% and 93% respectively, the sensitivity in this study is lower which is may be due to the difference in the number of cases under the study. The specificity and sensitivity of the test is higher than Apraxia Battery for Adults (ABAII) as the ABAII assesses verbal apraxia only but the test designed in the current study assesses all types of apraxia.

It is recommended toconvey the study on larger scale to get normative data that would provide more reliable normal-pathologic boundaries to provide measurement of the degree of severity of the disorder. Applying such kind of holistic motor programming skills assessment on cases post CVI is recommended in order to obtain a comprehensive profile of their difficulty due to lack of programming and motor co-ordination. This would help to address their difficulties in their rehabilitation program.

In conclusion, all types of apraxia had negative influence on the quality of life of the patients, but the most influential type is ideational apraxia.A comprehensive assessment protocol that covers all types of apraxia is mandatory because of the presence of combined different types of apraxia in the same patient. The highest percentage among types of apraxia in the current study is verbal apraxia followed by limb apraxia. The commonest combination is that between verbal apraxia and bucco-facial apraxia. The test designed in the current study showed statistically satisfactory specificity while the sensitivity was high in some types of apraxia only. The test designed in the current study showed validity, reasonable reliability and internal consistency.

CONFLICT OF INTEREST

There are no conflicts of interenst.

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APPENDIXES

Appendix 1: Questionnaire

Questions	√	X
-Questions about self-care:		
1. Can you dress yourself?		
2. Can you brush your teeth correctly?		
3. Can you make a cup of tea?		
4. Can you make a sandwich?		
-Questions about social life:		
1. Do you share in family gathering constantly?		
2. If you invited to an event, will you go?		
3. Do you have friends?		
4. Do you have problems in understanding others?		
5. Do you have to write for people to understand you?		
Questions about psychiatric health:		
1. Do you suffer from anxiety or depression?		
2. Have you ever visited a psychiatrist?		
3. Do you take any psychiatric medications?		
4. Have you tried group therapy?		
-Questions about the ability to work:		
1. Do you still have your job?		
2. Do you still perform you job in a perfect way?		
3. Do you need help in your work?		
4. Do you have to minimize your work hours?		
5. Did your condition affect your income?		
Questions	√	X
-Questions about specific daily life activities:		
1. Do you suffer of any speech problem?		
2. Has anyone mentioned it before?		
3. Has your speech problem changed?		
4. Has it returned to normal?		
5. Do you need help to speak?		
6. Do you have problems with chewing?		
7. Do you have sialorrhea?		
8. Do you have problems with food manipulation?		
9. Do you suffer from food collecting in your cheek or palate?		

Appendix 2: Bucco-facial apraxia

Test	Yes	No
***Face** At rest 1-Symmtry 2-Any apparent paralysis		
Imitation: 1-Wrinkled forehead 2-Grimace		
Passive range of motion 1-Check strength		
***Lips** At rest: 1-Symmetry 2-Closure. 3-Tremor 4-Deviances		
Rest **1-Lip retracted** **2-Lip pursed** **3-Drooling**		
Imitation 1-Symmetry of movements 2-Round lips. 3-Draw corner back 4-Open and close lips. 5-close lips and buff check		
Lower lips 1-Move mouth side to side. 2-Resistance		
Soft palate and pharynx At rest 1-Symmetry 2-Palatine tonsils 3-Cleft 4-Uvula -Bifurcated -Asymmetrical		
Imitalion: 1-Vertical movement (sustained /a/) 2-Lateral movement (sustained /a/)		
Tounge At rest: 1-Devialion 2-Size: -Too large -Small -Normal 3-Tone: ↑-↓- normal 4-Frenum: Normal-short-long		
Thrusting Exaggerated Protrusion 2-Decreased protrusion 3-Symmetrical		

PROM
1-Tounge moves toward pressure applied to gums
2-Body at the tongue moves toward
-Lower lateral gum
-Check
-Upper lateral gum
3-Mild blade deviation
4-Toung tip elevation
5-Surface: fasciculation atrophy-flat thick-bunched
6-Resting position:
-Protruded outside mouth
-Retracted
-Midline

Imitation:
1-Protrusion
2-Retraction
3-Lateralization
4-Tip deviation
5-Tip drawn back along hard palate
6-tip depression
7-Move tongue independently of jaw
8-Back elevation
9-Resistance
10-Cupping

Jaw
At rest
1-Size: too large-Too small –normal
2-Opening: Wide-restricted normal
3-Deviation
4-Assymmetry
5-Mobility:
-Open/close
-chewing
-side to side

Imitation
1-Graded opening wide-restricted-normal
2-Lateralization
3-Protrusion
4-Jaw thrust
5-Resistance
6-Jaw click