

Diagnostics and Assessment of Stroke Tests. A Detailed Description of the National Institutes of Health Stroke Scale (NIHSS): A literature review

Iaroslav Faizullin^{1*}, Rezeda Bodrova² and Elena Faizullina³

¹Attending physician at the Department of Rehabilitation and Sports Medicine, Kazan State Medical Academy, Kazan, Russian Federation

²Associate Professor, Head of the Department of Rehabilitation and Sports Medicine, Kazan State Medical Academy, Kazan, Russian Federation

³Professor of the Department of Dermatology, Venereology and STD, Kazan State Medical University, Kazan, Russian Federation

***Corresponding Author:** Iaroslav Faizullin, Attending physician at the Department of Rehabilitation and Sports Medicine, Kazan State Medical Academy, Kazan, Russian Federation.

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Abstract

Background: Stroke is an acute neurological disorder when the blood supply to the brain is cut off and remains the third spread reason of the death after the myocardial infarction and tumors in many industrial developed countries. It is also considered as one of the main reasons of disability and requires substantial patient's care.

Objectives: Objectives of the current work include defining various tests that are helpful in recognizing a stroke as an acute condition.

Methods: A number of articles on rehabilitative test were summarized. Various tests were chosen for the review that authors consider to be relevant in the field of the stroke diagnostics. The current article is a literature review.

Result: The NIHSS conveys more comprehensive view of the patient's reactions and abilities. Major strengths: easy to use, comprehensiveness, the test may be used at home and in the hospital, no need in special equipment.

Conclusion: The National Institutes of Health Stroke Scale is a test that assesses a patient based on 0 to 42 scoring system showing an excellent test-retest reliability of the test ICC = 0.93. In comparison with to this test, test-retest reliability of Canadian Neurological Scale is not established. A criterion validity of the National Institutes of Health Stroke Scale (NIHSS) described in the table below shows adequate correlation with hospital charges ($r = 0.320$). NIHSS provides an opportunity for a comprehensive non-instrumental assessment of consciousness, speech and many other human abilities.

Keywords: Stroke; Stroke scales; Action Research Arm Test; Canadian Neurological Scale; The National Institutes of Health Stroke Scale

Introduction

Definitions: Stroke is an acute neurological disorder, i.e. brain attack, when the blood supply to the brain is cut off. There are two types of stroke: ischemic and hemorrhagic: The first type of stroke occurs when the blood supply is cut off the brain and the second one is caused by bleeding in or around the brain [1].

Epidemiology: Stroke is the third spread reason of the death after the myocardial infarction and tumors in many industrial developed countries. It is also considered as one of the main reasons of disability and requires substantial patient's care. Every year from 200 until 700 strokes occur among 100,000 people in Europe and around 200 among 100,000 people in Germany and it is rising [2].

According to Donnan, *et al.* [3], the stroke takes not the third but the second place among the most spread reasons of death after the ischemic heart disease, and causes around 9% of all diseases worldwide. The study published by Naghavi, *et al.* revealed that the overall number of deaths from the stroke was 12%, accounting 6.4 millions of deaths in total [4].

Risk factors: The most important risk factor for the stroke is the arterial hypertension - a medical condition when a blood pressure persistently elevates. The elevation of a blood pressure on 7.5 mm Hg could double a risk of the stroke [2]. Other risk factors include diabetes mellitus, obesity, lack of physical activity, high blood cholesterol and others [5].

Moreover, risk factors of the stroke could be subdivided into two groups: factors that cannot be changed, and factors that can be changed, treated or controlled. The first group includes race, family history, age, gender and also the current stroke, transient ischemic attack or heart attack. The changeable factors are, for instance, a high blood pressure, smoking, alcohol intake, diabetes mellitus, poor diet, low rate of physical activity, and others [6].

Symptoms: Many signs and symptoms of the stroke could be diagnosed even at the beginning. Those could occur simultaneously or separate. The symptoms of the stroke include difficulties in speaking and/or understanding others' speech, or even loss of speech; severe headache occurring without previous reason; loss of vision in one or both eyes; loss of balance or falling down; weakness of the face, arm, leg or its numbness on one side of the body [7].

Indication-specific limitations: Based on the International Classification of Functioning, Disability and Health (ICF), limitations occur in body functions and structures, activity and participation on the patient [8]. Body functions include, for instance, the following:

1. b110 Consciousness functions - include general mental functions, clarity and continuity of the wakeful state, e.g. coma, stupor, vegetative states etc.
2. b114 Orientation functions - describe the ability of a person to be oriented in place and knowing one's relation to self, to time and surroundings and include understanding that relation properly (orientation). Stroke patients may be disoriented in place.
3. b140 Attention functions - reacting properly on an external stimulus and includes, for example, concentration or distractibility. Stroke patients may be distracted, showing weak attention functions.
4. b144 Memory functions - the ability to retrieve information during the different time period. In Stroke patients may suffer from anterograde or retrograde amnesia, memory span etc.
5. b167 Mental functions of language - the ability to recognize specific signs, symbols and other components of language. Stroke patients may experience loss of ability to speak known as aphasia.
6. b730 Muscle power functions - relate to power generated by contraction of different groups of skeletal muscles, include passive and active resistance. Stroke patients may experience impairments such as weakness of small muscles of feet and hands or severe disorders: paraplegia, quadriplegia, etc.

Body structures including anatomical parts of the body that may be affected by the stroke.

- s110 Structure of brain
- s730 Structure of upper extremity
- s750 Structure of lower extremity

Activities describe actions that patient makes himself/herself related to the task and participation describes his/her involvement in the life situation. Activities and participation usually come up together and include speaking, walking, washing oneself, toileting, dressing, eating, etc. Stroke patients have problems with these tasks if they experience difficulties in body functions described above.

Objectives

Objectives of the current work include defining various tests that are helpful in recognizing a stroke as an acute condition.

Purpose of assessment: The assessment of patients with the stroke is becoming increasingly important nowadays. National Stroke Association [9] reports that when a blood flow to the brain is blocked, a patient losses around 1.9 million neurons per minute, which results in the person's movement, speech or memory could be affected or even lost. The purpose of tests is to enable the pedestrians, relatives, friends or patients to be able to first-hand diagnostics of the stroke in order to provide first aid and call the emergency immediately, so that the patient gets the qualified medical support as soon as possible that could save one's health condition or life.

Methodology

A number of articles on rehabilitative test were summarized. Various tests were chosen for the literature review that authors consider to be relevant in the field of the stroke diagnostics.

Test Instruments

Express-diagnostics of the stroke: One of the simplest methods that may help diagnosing the stroke in short time is the Face Arm Speech Test - FAST. Face could look uneven, the drooping grimace may yield the sign of the stroke (face weakness), arm becomes weak (arm weakness), speech - faltering, the patient may experience difficulties in pronouncing whole words or syllables, and "T" corresponds to time to call ambulance that is very important to screen the brain earlier [10]. The available evidence seems to suggest that this method is widely used by paramedics during express-diagnostics of the stroke before patient's hospitalization and it is achieving high levels of detection [11]. Furthermore, Berglund., et al. [12] who were analyzing phone calls of emergency patients, described the FAST test as an important while calling an emergency and revealed the presence of FAST symptoms in 80% of stroke patients.

Specific Diagnostics: Different diagnostic methods could be used in order to distinguish the stroke. Computed tomography (CT) is used to show the type of stroke and what kind of damage it may have caused. For the more detailed picture the magnetic resonance imaging (MRI) is used. The research by Chalela., et al. shows that MRI provides more information about acute ischemia of the brain, can better diagnose acute or chronic hemorrhage and, consequently, should be preferred while used on patients with suspicion of the acute stroke rather than CT [13]. Moreover, blood tests are used to help diagnosing the stroke - the low glucose level may suspect this disease, electrocardiogram (ECG) - to exclude the myocardial infarction, and Doppler ultrasound to measure blood flow and blood pressure [14].

Action research arm test (ARAT) is one of the most spread standardized measures for stroke rehabilitation. The ARAT bases on the ICF domain "Activity" and measures the ability of the patient to handle and manipulate objects that are differing in size, weight and shape, i.e. this test specifies on the upper limb functioning using observational methods. This test consists of 19 items that are grouped into four sub-tests: grasp, grip, pinch, and gross movement. For the grasp subtest the patient is asked to grasp, lift vertically, place and release each object to the desired location.

For the grip sub-test it is required to pour the glass of water, and transfer different tubes from one place to another. For the pinch test the patient is asked to grasp small objects from one location to another [15]. Finally, the gross movement includes touching top and back of head, and touching mouth. The total score of ARAT ranges from 0 to 57 where the highest score indicates the best performance. The test requires around 10 minutes to be performed depending on number of items that are going to be tested, does not require any previous training and is free of charge.

Equipment that is used during ARAT includes the following: various size wood blocks, a cricket ball, a stone, jug and glass, a tube, a washer with bolt, ball bearing and a marble. The target group is patients with stroke, multiple sclerosis (MS) and traumatic brain injury (TBI). The performance on each item is assessed according to the following four criteria:

3 - Performs test normally; 2 - Completes the test but requires more time to do or has difficulties in performing; 1 - Performs test partially; 0 - Cannot perform the test.

Lyle [16] describes the following procedure of scoring the test: patients who achieve the maximal score in the first sub-test get three points in other categories - subsequent scores on that scale. If the patient gets less than three points in the first scale, the other scale is assessed. If patient gets zero points for that, he is unlikely to get more than 0 in the rest items and is credited 0 points there. The study of Platz., *et al.* [17] has shown an excellent test-retest reliability (Appendix). The study of van der Lee., *et al.* [18] shows an excellent inter rater reliability (ICC = 0.995) and the publication of Platz., *et al.* [17] revealed an excellent inter rater reliability (ICC = 0.989).

Canadian Neurological Scale: The scale provides the standardized neurological assessment of cognitive and motor functions of stroke patients. The test is used to assess the alertness of stroke patients and includes the following assessments: level of consciousness, orientation, aphasia and motor strength [19]. The test is subdivided into two parts: the first one aims to reveal how the patient is able to understand and follow instructions and the second one administers the presence of comprehension deficits, and lasts from 5 to 10 minutes. Based on ICF, the scale tests body functions and patient's activities.

The equipment is not necessary for conduction of the test and no training is required. Furthermore, the test is free of charge; only stroke patients belong to the target group. Bushnell., *et al.* [20] show that the Canadian Neurological Scale has an excellent inter-rater reliability (ICC = 0.97; raters = 2 neurologists) and Cote., *et al.* [21] declare the scale has an excellent intra-rater reliability ($r = 0.924$; correlation of nurse and physician ratings). Unfortunately, the literature search yielded no data regarding the test-retest reliability. Furthermore, an excellent correlation between the Canadian Neurological Scale and a standard neurologic examination was noticed with $r = 0.769$ [21]. Nevertheless, responsiveness of the method and floor/ceiling effect of the scale was not established.

Stroke-Adapted Sickness Impact Profile: The test includes overall 30 items; each item describes the behavior of the patient that could be affected by the disease or some other aspect of human life. Patients are asked to fill in descriptions of them on a given day where answers include two options: "yes" or "no". To score the scale, weights are applied to marked items, summed for each subscale and expressed as a percentage for each subscale ranging from 0 to 100%. Moreover, there are eight subscales: body care and movement, social interaction, mobility, communication, emotional behavior, household management, alertness behavior and ambulation. Subscales may be also combined in two dimensions: physical and psychosocial. According to ICF, it relates to body functions and aimed at stroke patients; The test does not require training and special equipment and demands only 30 minutes to administer [22].

Chedoke Arm and Hand Activity Inventory-7: The test provides an opportunity to inquire whether not only damaged hand could perform well but also the function of both arms after the stroke. The test relates to the ICF domain "Activity" and requires 30 minutes to be performed. There are thirteen items in the test: a jar of coffee, a phone, ruler and pen, a toothpaste and a toothbrush, a knife, a fork, putty, a glass of water, wet washcloth, eyeglasses, a jacket and zipper, a shirt with five buttons, a towel, a rubber-maid 38 liter container (50x37x27cm) with 10 lb. weight, a plastic grocery bag with 4 lb. weight. Training required for performing the test includes test instructions and getting familiar with test procedures.

The test is free of charge. All 13 items are scored using a 7-point quantitative scale. Total scores are obtained by summing the item scores and thus can range from 13 to 91. Higher scores indicate greater ability to do tasks [23]. According to Barreca, *et al.* [24], Chedoke Arm and Hand Activity Inventory-7 demonstrates excellent reliability (ICC= 0.98) and internal consistency (ICC = 0.95). Nevertheless, the literature search revealed no results regarding content validity, construct validity, responsiveness and floor/ceiling effects of the method.

Detailed description of the test

The National Institutes of Health Stroke Scale (NIHSS) has been chosen for the detailed description. This is a disease-specific scale based on “Body Function” according to ICF, measuring the severity of symptoms associated with cerebral infarcts. The target group of the test is stroke victims; The scale is based on questionnaire and interview and consists of fifteen items [25]

“...assessing severity of impairment in LOC, ability to respond to questions and obey simple commands, papillary response, deviation of gaze, extent of hemianopsia, facial palsy, resistance to gravity in the weaker limb, plantar reflexes, limb ataxia, sensory loss, visual neglect, dysarthria and aphasia severity” (title page) Items are graded according to 3 to 4 scales, 0 meaning no impairment. According to Brott, Adams., *et al.* [26], there are following severity grades: very severe: > 25, severe: 15-24, mild to moderately severe: 5-14, mild: 1-5. The length of the test is 6 minutes, however, the total length of NIHSS is not indicated, but could last around 25-30 minutes. More details are provided in the table below.

Results

The test is applicable for all types of population and both genders. The test is used to suspect a stroke or for more in-depth diagnostics rather than Face Arm Speech Test. NIHSS is a useful test in clinical practice. The test was first described by Brott, *et al.* [26], Goldstein, Bertels, Davis [27]. Purpose of application of the test is to get more information about the probable location of the haematoma or ischaemia, get more comprehensive view of the patient’s reactions and abilities. Major strengths of the test are the easiness to use, comprehensiveness, the test may be used at home and in the hospital, no need in special equipment. Weaknesses are not so significant, however, the test may last long- over than 30 minutes.

Name of test	National Institutes of Health Stroke Scale (NIHSS)
Author(s)	Brott, Adams., <i>et al.</i> [26] Goldstein, Bertels., <i>et al.</i> [27]
References	Adams, Davis., <i>et al.</i> [28] Brott, Adams., <i>et al.</i> [26] Fink, Selim., <i>et al.</i> [29] Goldstein, Bertels., <i>et al.</i> [27] Goldstein & Samsa [30] Kasner [31] Rundek, Mast., <i>et al.</i> [32] Schlegel, Kolb., <i>et al.</i> [33]
Characteristics/aims	The test is used as a quantitative measure of neurological deficit post stroke.
Content	Measures the severity of symptoms associated with cerebral infarcts;

Detailed test description	<p>Provide a detailed description of the conduct of the test, i.a. including:</p> <p>Test environment, necessary equipment and other resources</p> <p>Test could be performed at the hospital. Usually is assessed by the physician. The test requires a questionnaire and an interview with the patient.</p> <p>Specific instructions</p> <p>Level of consciousness (LOC)</p> <p>LOC responsiveness- attempting a verbal stimulus to alert the patient- max. score:3</p> <p>LOC Questions- ask his/her name and current month; max. score:2</p> <p>LOC commands- open and close eyes, then asking for grip and release hand; max. score:2</p> <p>Horizontal eye movement- ask to follow the pen or a finger; max. score:2</p> <p>Visual field test- cover one eye and then another; max. score: 3</p> <p>Facial palsy- asking to smile, close eyes; max. score: 3</p> <p>Motor arm- asking patient to extend his/her arm: 90 degrees when sitting and 45 degrees when lying; max. score: 4</p> <p>Motor leg- asking to place the leg to 30 degrees; max. score: 4</p> <p>Limb ataxia- asking to touch patient’s (his/her own) nose, the finger of instructor and then repeat 3 or 4 times; max. score: 2</p> <p>Sensory- using a pin. Asking a patient whether he feels sharp or not; max. score: 2</p> <p>Language- showing pictures and asking for oral description; max. score: 3</p> <p>Speech providing sentences and asking the patient to read out loud; max. score: 2</p> <p>Extinction and inattention- to show the patient 2 fingers and ask which of them are wiggling; max. score: 2</p> <p>Measures of standardization Not established</p> <p>Conducting the test</p> <p>The patient should be in bed or sit on the chair if his health condition efforts.</p> <p>Interpretation of test results & scoring</p> <p>0 No symptoms of stroke</p> <p>1-4 Minor</p> <p>5-15 Moderate</p> <p>16-20 Moderate to severe</p> <p>21-42 Severe</p>	
Target population	Age:	None declared. Assessed in patients with a stroke or suspicion of a stroke.
	Indications:	Stroke patients
Test realization	Space/environmental demands:	A bed, patient’s room or sitting on the chair
	Time/personal demands:	None administrated
	Material/equipment:	A needle, a book with pictures for patient’s description and interpretation, a book with sentences for checking patient’s speech
	Scoring/interpretation:	<p>Scores of < 5; 80% of stroke survivors will be discharged to home</p> <p>Score between 6 and 13 typically require acute inpatient rehabilitation</p> <p>Scores of >14 frequently require long-term skilled care (32, 33)</p>

<p>Psychometric quality criteria</p>	<p>Reliability/Objectivity:</p> <ul style="list-style-type: none"> • Test-retest/intra-rater/inter-rater <p>Excellent test-retest reliability; ICC = 0.93 (30) Excellent inter rater reliability; ICC = 0.95 (30)</p> <p>Adequate to Excellent agreement was found for 9 of the 13 items on the NIHSS (Kappa = 0.32 to 0.79); lowest levels of agreement were found for the Facial palsy (Kappa = 0.22) and limb ataxia (Kappa = -0.16) items. [27]</p> <ul style="list-style-type: none"> • Internal consistency Not established • Measurement error Not established
	<p>Validity:</p> <ul style="list-style-type: none"> • Content validity (incl. face validity) <p>Items are based on components of a standard neurological examination (Kasner, 2006)</p> <ul style="list-style-type: none"> • Criterion validity (predictive/concurrent) <p>Retrieved from https://www.sralab.org/rehabilitation-measures/national-institutes-health-stroke-scale</p> <p>Acute Stroke: Predictive validity (Adams., et al. 1999; n = 1268)</p> <ul style="list-style-type: none"> • NIHSS scores at baseline predicted outcome at 7 and 90 days • An excellent outcome was achieved by nearly two-thirds of the survivors who scored 3 or less at day 7 • Only a few patients who scored more than 15 at baseline achieved excellent outcomes after 90 days <p>Acute Stroke: Predictive validity (Baird., et al. 2001; n = 66; <48 hours post-stroke) NIHSS combined with Magnetic Resonance Diffusion-Weighted imaging (MR DWI) and volume of ischaemic brain tissue on MR DWI significantly predicted stroke recovery</p> <p>Acute Stroke: (Bohannon., et al. 2002; n = 92, mean age = 70.0 (12.4) years; NIHSS was administered while patients were still in the emergency department, prior to admission)</p> <ul style="list-style-type: none"> • Poor* (but significant) correlation with length of stay (r = 0.276) • Adequate* correlation with hospital charges (r = 0.320) • Adequate* correlation with discharge destination (home or elsewhere) (r = - 0.355) <p>*Significant at p < 0.05</p> <p>Acute Stroke: Concurrent Validity (29)</p> <ul style="list-style-type: none"> • Adequate to Excellent correlations with diffusion weighted MRI lesion volumes (r = 0.48 right, r = 0.58 left); and perfusion-weight hypo perfusion volumes (r = 0.62 right, r = 0.60 left) • Construct validity (i.a. convergent/discriminant) <p>Retrieved from https://www.sralab.org/rehabilitation-measures/national-institutes-health-stroke-scale</p> <p>Acute Stroke: (32, 33)</p> <p>Outcomes related to NIHSS scores at admission:</p> <ul style="list-style-type: none"> • Scores of < 5; 80% of stroke survivors will be discharged to home • Score between 6 and 13 typically require acute inpatient rehabilitation • Scores of >14 frequently require long-term skilled care

	Sensitivity/specificity: Not established
	Responsiveness: Acute Stroke: (Brott., <i>et al.</i> 1989) NIHSS scores were compared to infarction size (measured by computed tomography) on 65 patients at 1 week post stroke. 10 items demonstrated an average of 25% change over 7 days. However, changes in limb ataxia and best gaze may have been overstated.

Table 1: Detailed description of the test- National Institutes of Health Stroke Scale (NIHSS).

Conclusion

The National Institutes of Health Stroke Scale described above is a test that is based on assessing the patient based on 0 to 42 scoring system. Goldstein & Samsa (30) justified an excellent test-retest reliability of the test ICC = 0.93. In comparison with this test, the test-retest reliability of the Canadian Neurological Scale was not established. The criterion validity of the NIHSS described in the table showed an adequate correlation with hospital charges (r = 0.320), and the criterion validity of Chedoke Arm and Hand Activity Inventory was not established.

The NIHSS provides an opportunity for a comprehensive non-instrumental assessment of consciousness, speech and many other human abilities. The test is used for both sexes and there are no age limitations. However, it would be interesting to conduct a research to gain information about sensitivity and specificity of the NIHSS test. In conclusion, the NIHSS deserves being widely used because of a good scientific evidence.

Conflicts of interest statement

The authors declare that there are no conflicts of interest.

Appendix

Chronic and Acute Stroke, Multiple Sclerosis & Traumatic Brain Injury: (Platz., *et al.* 2005; n = 23)

Interrater Reliability (between 2 raters)			
Action Research Arm Test:			
	Rating	ICC	rho
Grasp	Excellent	0.949	0.965
Grip	Excellent	0.947	0.955
Pinch	Adequate	0.894	0.897
Gross movement	Excellent	0.976	0.976
Total score	Excellent	0.965	0.968
Fugl-Meyer Test, arm section			
	Rating	ICC	rho
A Shoulder/elbow/forearm	Excellent	0.954	0.944
B Wrist	Excellent	0.973	0.961
C Hand	Excellent	0.958	0.941
D Co-ordination/speed	Excellent	0.936	0.947
Total motor score	Excellent	0.965	0.951
Sensation	Adequate	0.806	0.672

Passive joint motion/joint pain	Excellent	0.946	0.883
Box and Block Test:			
	Rating	ICC	rho
Total	Excellent	0.963	0.973

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