

THE IMPAIRMENTS OF SENSORIMOTOR HAND FUNCTIONS IN STROKE PATIENTS - THE COMPARISON OF THE RESULTS OF A CLINICAL ASSESSMENT AND THE ASSESSMENT UTILIZING THE STANDARD TESTS (A CASE STUDY)

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The impairments of sensorimotor hand functions after a stroke have a negative impact on the subject's interaction with external settings and on performing common daily and working activities and thus on the quality of his or her life (Carey, 1995). Since the structure and function of the cerebral cortex is capable of after stroke modifications, new therapies are being looked for that support the desirable plasticity of the central nervous system to the maximum. The main condition for a successful treatment is a reliable target focused examination of all hand functions affected by the stroke. This requires both a differentiated and complex examination.

This study presents the results and experience of treating patients hospitalized after a stroke. The impaired motor and somatosensory functions have been assessed through somatosensory and manipulation tests. In three case studies, the differences are pointed out between the results of the clinical neurological hand examination and the functional hand examination. Both examinations use target focused specialized tests.

Keywords: Stroke, post stroke hand, sensorimotor functions, hand function tests, neurological examination.

INTRODUCTION

After stroke the loss of differentiated hand motility occurs and activities move towards the shoulder girdles. The impairments of sensorimotor functions of the hand develop into the disability to carry out and to take control of the grasp, to hold various objects, to handle them, to combine compound movements, to recognize the surface of an object by the fingertips of the fingers and accordingly to adapt the strength of pressure (Mayer & Hlušík, 2004; Carey, 1995). The relation of sensory and motor functions is a topic of longstanding research. Recently, the research has focused on the relationship between these functions in performing real activities of daily living. Obviously, the impairment of somatosensory performance can be the main reason of dysfunction, particularly of hand (Carr & Shepherd, 1998).

In patients with central lesion we can find variously high sensation deficiency, occurring contralaterally, ipsilaterally or bilaterally, as well. Routine examination does not have to reveal the presence of all impairments of sensorimotor functions. Ignored and uncorrected impairments can later be the cause for resulting patient's dexterity during common handling activities, which can be very frustrating for him, it can enhance the risks for his damage and for him it can mean complications in social contacts.

Our experience from the clinical practice has brought us to the consideration if the standard entry neurological examination of stroke patients are sufficient to:

- assess the patient's current condition and, in detail, all the impairments of his sensorimotor functions,
- choose appropriate therapeutic procedures to adjust the impairments,
- perform sufficiently sensitive control examinations,
- conclude the prognosis of next process of the disease and adjustment of the impairments.

The aim of this study is to demonstrate on three case studies the differences between the results obtained through standard examination of sensorimotor functions by a neurologist from the results obtained through standardized tests used in rehabilitation.

METHODS

According to the case studies of three patients who were treated in Faculty hospital Ostrava in Ostrava-Poruba we show different findings during the examination by standard neurological tests and during more detailed examination by special tests created for sensation impairments and handling functions.

All of the three patients suffered from ischemic stroke of arteria cerebri media (ACM). They were treated in the department of clinical neurology and later transferred to the rehabilitation in patient department. In the enclosed documentation we obtained the results of a check out examination by a neurologist and the entrance examination by a rehabilitation doctor. The patients were two men and one woman who were, according to the results of neurological examination, among the patients with low level of disability.

The patients were selected according to the following criteria: aged between 45–75, without aphasia, neglect syndrom, polyneuropathy, and with ability to cooperate.

In all patients we used eight tests for evaluating sensorimotor functions:

- three neurological tests: NIH SS – National Institutes of Health Stroke Scale (Brott et al., 1989), Mingazzini's trial and modified Ashworth's scale of spasticity;

- two sensation tests: FMT – The Fabric Matching Test (Carey, Oke, & Matyas, 1997) and RASP – The Rivermead Assessment of Somatosensory Performance;
- three motor skill tests: FRT – The Functional Reach Test (Duncan et al., 1990), NPHT – The Nine Peg Hole Test (Mathiowetz et al., 1985) and TMF – The Manipulating Hand Functions Test by means of the set of blocks Ministav (Vyskotová & Vaverka, 2003) – see TABLE 1.

With all three patients we show the results of examination and assessment of sensorimotor functions of upper extremities by chosen scales, tests and trials (TABLES 2, 3, 4). For better clarity we also show these results in graphic form (Diagrams 1, 2, 3). The results of sensation tests are demonstrated in percentages there. For better clarity and to enable the comparison to other tests, the results of motoric tests measured in seconds were recalculated in percentage rate in relation to expected standard (Vyskotová, 2003).

TABLE 1

Scales, tests and trials used

Title of the test	Test characteristics
NIHSS (National Institutes of Health Stroke Scale)	Standardized clinical assessment of neurological results/deficits and level of regeneration. It assesses eleven issues: level of consciousness (3 issues), speech, neglect, viewing field, oculomotorics, paresis n. facialis, motorics of the upper limb, motorics of the lower limb, ataxia, dysarthria, and sensation. The test criterion is the achieved score.
Mingazzini's trial	Basic orientation trial for symptoms of paralysis in the upper extremities. In compliance with the lowering of the arm and raising it forward (cm/s) with slightly closed eyes, medium grave and grave paralysis can be assumed.
Modified Ashworth's scale of spasticity	Scale for assessing muscle tone and spasticity. It is assessed on a scale of 0–4.
The rivermead assessment of somatosensory performance	Test for assessing somatosensory functions in neurological diseases. It contains seven subtests: sharp/dull discrimination, surface pressure touch, surface localization, bilateral touch discrimination, two point discrimination, temperature discrimination, proprioception movement discrimination, and proprioception direction discrimination. The test criterion is the achieved score.
The fabric matching test	Test for assessing sense discrimination focused on the surfaces of various fabrics. Part of it is a set of ten standardized fabric surfaces, which range on a scale from the softest to the roughest. The goal is to distinguish the variety and to match identical surfaces. The test criterion is the achieved score.
The functional reach test	This test measures balance with the help of assessing stability limits in a forward direction. It is defined as the difference between the length of the arm and the maximum to which onward reaching can be done while maintaining a permanent basis of support in a standing position. The validity of the test derives from measurements of an action commonly performed in the activities of daily living.
The nine peg hole test	Test for assessing fine motorics. The patient's task is to place, as quickly as possible, nine pegs into holes in a testing board and then to pick them up with one hand, one by one, and to put them into a bowl. Unimanual dexterity of the fingers is tested. The test criterion is the achieved time.
The manipulating hand functions test by means of the set of blocks Ministav	This test assesses handling skills, unimanual and bimanual, by means of five objects of the special set of blocks "Ministav", which are called Needle, Cube, House, Pyramid and Mummy. As a whole, it is made up of 17 subtests, in which tasks such as the composition and decomposition of objects, including the composition of an object being held up as an example, with the palmar and pinch grasp or by putting a needle through holes into an object, are performed. The test criterion is the achieved time.

Case study 1

Patient 1 – man, 52 years old, right handed. Hospitalized from 31. 8. 2006 to 13. 9. 2006 at the neurological department and from 13. 9. 2006 to 12. 10. 2006 at the inpatient department of rehabilitation.

Diagnostic summary (neurological report after discharge): central sinistral spastic-ataxic hemiparesis, central facial paresis on the left and dysarthria as a result of ischemia in ACM on the right. Cardioembolic etiology, NIH SS 4.

According to the results of neurological tests (TABLE 2) received by the preliminary examination of the patient at the in patient rehabilitation department it follows that there is a slight disability (NIH SS 1), without presence of paresis (Mingazzini test in norm), with hypertonic (spastic) flexors of the elbow joint of the left upper limb (based on modified Ashworth's scale level 2).

Somatosensory functions of the left upper limb: according to the results of FMT the patient had a severe

impairment of sense discrimination for fabric matching (assessed as anesthesia) and according to RASP for modality of two points discrimination assessed as anesthesia as well. In proprioception movement discrimination and in proprioception direction discrimination he achieved 33% of the standard performance and approximately 60% of the standard performance for modality of "distinction of sharp and dull objects" and "localization of touching". In the modality "slight pressure touching" he reached 91% of the standard performance. All sensorimotor functions of the right upper extremity were standard.

Motor functions: dynamic balance was bilaterally assessed as normal, fine motoric in terms of NPHT on the left as damaged (Fig. 1) for non performance of time limit. By means of TMF the deceleration of manual composition and decomposition subtests called Pyramid and Mummy was found in manipulating functions and the patient was not able to press and uphold the object called House by the help of palmar and pinch grasp of his left hand. The examination at common daily activities by means of Barthel's index: 85 points.

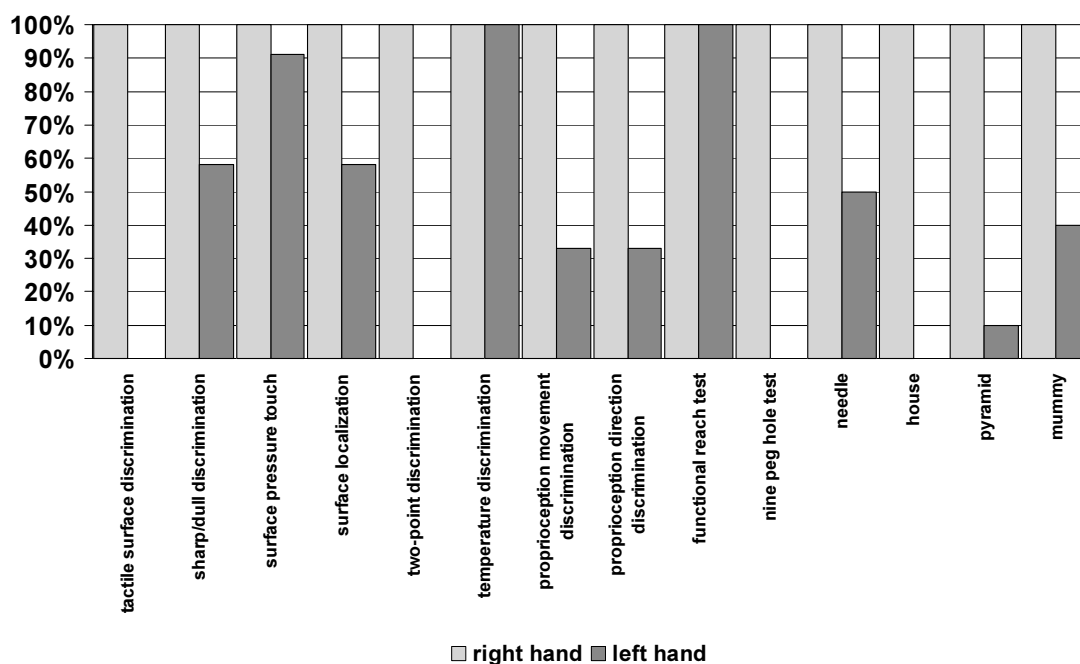
TABLE 2

Examination and assessment of sensorimotor functions of the upper extremities by means of selected scales, tests and trials

Examination	Modality	Right upper limb	Left upper limb	Assessment
NIH SS				1 – slight deficit
Mingazzini		norm/standard	norm/standard	norm/standard
Ashworth		0	2	norm/standard except for flexors of the elbow joint
FMT	tactile surface discrimination	norm/standard	0 – total loss	anesthesia of the left hand
RASP	sharp/dull discrimination	norm/standard	58%	hypo-aesthesia more on the left
	surface pressure touch	norm/standard	91%	slight hypo-aesthesia
	surface localization	norm/standard	58%	hypo-aesthesia
	two point discrimination	norm/standard	0 – total loss	anesthesia of the left upper limb
	temperature discrimination	norm/standard	norm/standard	norm/standard
	proprioception movement discrimination	norm/standard	33%	damaged
	proprioception direction discrimination	norm/standard	33%	damaged
FRT	dynamical balance	norm/standard	norm/standard	norm/standard
NPHT	fine motorics	norm/standard	over 30s	damaged on the left
TMF	manipulating functions – needle	norm/standard	deceleration	deceleration of effort of the upper limb
	house	norm/standard	is not able to do	he can not uphold the object using the left upper limb
	pyramid	norm/standard	distinct deceleration of effort	deceleration of effort during the composition of the object
	mummy	norm/standard	deceleration	deceleration of composition

Diagram 1

Sensorimotor hand functions tests

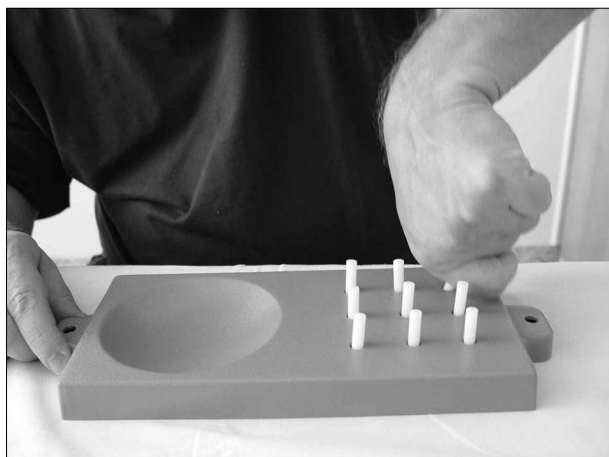
**Legend**

For better clarity the measured data of motoric tests assessing the performance according to the achieved time were averaged and converted to percentages.

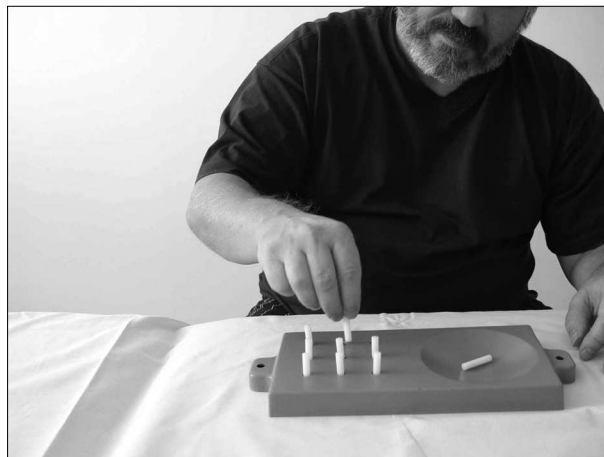
Fig. 1

The assessment of fine motorics by means of NPHT

a)



b)

**Legend**

The comparison of the effort of the right and left hands. Obviously on the left, the damaged grasp stereotype can be seen. The patient was able to fulfil the task but he did not perform within the time limit.

Case study 2

Patient 2 – man, 68 years old, right handed. Hospitalized from 22. 3. 2006 to 12. 4. 2006 at the neurological department and from 18. 4. 2006 to 12. 5. 2006 at the inpatient department of rehabilitation.

Diagnostic summary (neurological report after discharge): residual discrete sinistral destructive hemiparesis, central facial paresis on the left as a result of ischemia in ACM on the right, v.s. cardioembolic etiology, NIH SS 1.

According to the results of neurological tests (TABLE 3) received by the preliminary examination of the patient at the in patient rehabilitation department it follows that there was no neurological deficit identified in this patient (NIH SS 0, Mingazzini test in norm, Ashworth's scale – level 0).

The examination of somatosensory functions of the left upper limb: according to the results of FMT the

sense discrimination was normal. The RASP test demonstrated a total loss of two point discrimination and in the modality “distinction of sharp and dull objects” the patient reached 83% of standard performance. All sensorimotor functions of the right upper extremity were normative, except for a slight deficit in the modality “discrimination of heat stimulation”.

The examination of motor functions: dynamic balance was bilaterally assessed as normal, fine motoric in terms of NPHT on the left as damaged (Fig. 1) for non performance of the time limit. By means of TMF the manipulating functions were assessed as deceleration of performance in the composition and decomposition subtests and the patient was not able to press and uphold the object called House (Fig. 2) with the help palmar and pinch grasp of his left hand. The examination at common daily activities by means of Barthel's index: 100 points.

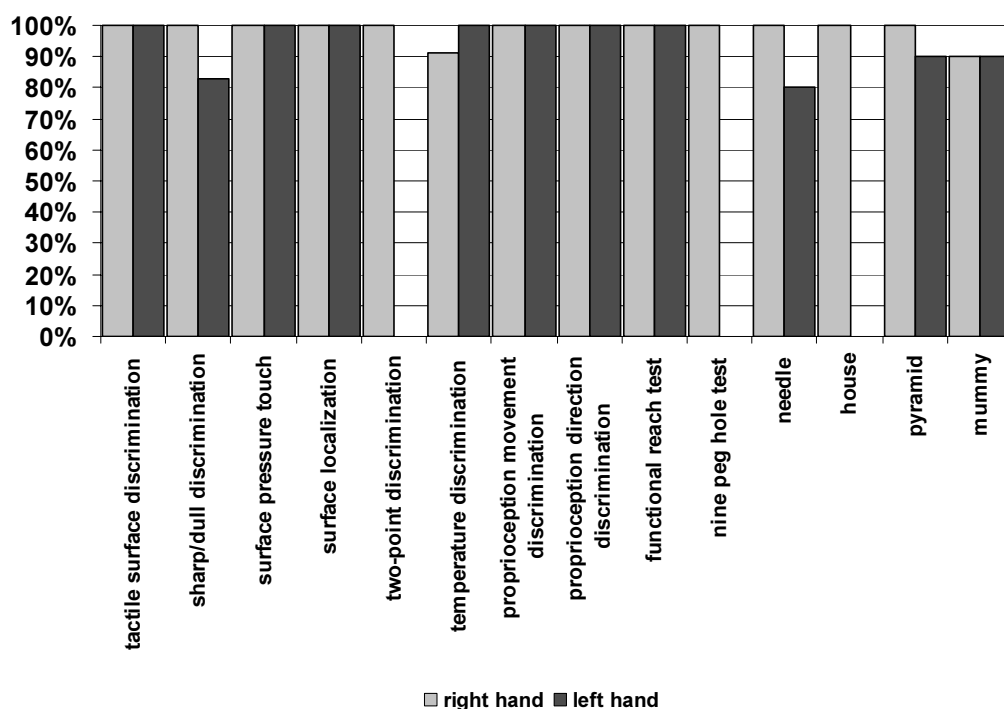
TABLE 3

Examination and assessment of sensorimotor functions of upper extremities by means of selected scales, tests and trials

Examination	Modality	Right upper limb	Left upper limb	Assessment
NIH SS				0 – norm
Mingazzini		norm/standard	norm/standard	norm/standard
Ashworth		0	0	norm/standard
FMT	tactile surface discrimination	norm/standard	norm/standard	norm/standard
RASP	sharp/dull discrimination	norm/standard	83%	slight hypo-aesthesia
	surface pressure touch	norm/standard	norm/standard	norm/standard
	surface localization	norm/standard	norm/standard	norm/standard
	two point discrimination	norm/standard	0 – total loss	anesthesia of the left upper limb
	temperature discrimination	91%	norm/standard	slight damage on the left
	proprioception movement discrimination	norm/standard	norm/standard	norm/standard
	proprioception direction discrimination	norm/standard	norm/standard	norm/standard
FRT	dynamical balance	norm/standard	norm/standard	norm/standard
NPHT	fine motorics	norm/standard	over 30s	damaged on the left
TMF	manipulating functions – needle	norm/standard	deceleration	deceleration of effort of the left upper limb
	house	norm/standard	is not able to do	he can not uphold the object by the left upper limb
	pyramid	norm/standard	deceleration of effort	deceleration of effort during composition and decomposition of the object
	mummy	deceleration	deceleration	deceleration of composition

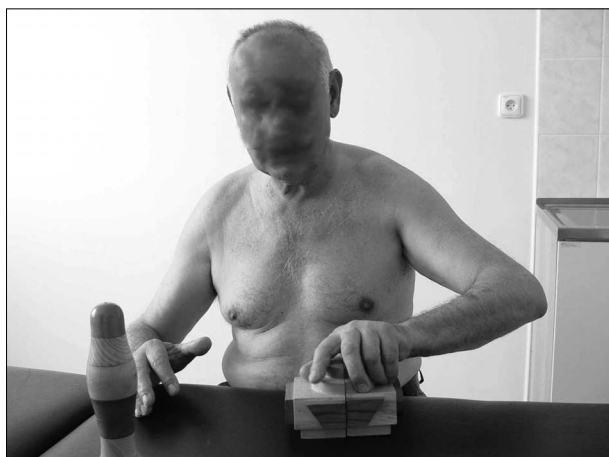
Diagram 2

Sensorimotor hand functions tests

**Fig. 2**

The assessment of fine motorics by means of NPHT

a)



b)

**Legend**

Subtest TMF “upholding the House by means of the palmar grasp” – the comparison of effort of the right and left hands. The patient did not manage to hold four parts of the House together by his left hand and to uphold the object. Associated movements of the right hand are visible (photo on the right).

Case study 3

Patient 3 – woman, 70 years old, right handed. Hospitalized from 11. 11. 2006 to 30. 11. 2006 at the neurological department and from 30. 11. 2006 to 14. 12. 2006 at the inpatient department of rehabilitation.

Diagnostic summary (neurological report after discharge): discrete central sinistral hemiparesis, central facial and hypoglossal paresis on the left and dysarthria as a result of ischemia in ACM on the right, NIH SS 4.

According to the results of neurological tests (TABLE 3) received by the preliminary examination of the patient at the in patient rehabilitation department it follows that there is a slight neurological deficit in this patient (NIH SS 3, Mingazzini test standard, Ashworth's scale – 0).

Somatosensory functions of the left upper limb: according to the results of FMT the patient had a grave impairment of sense discrimination for fabric matching (assessed as anesthesia). The RASP test demonstrated intact two point discrimination and proprioception movement discrimination. Other modalities were damaged (TABLE 4). All sensorimotor functions of the right upper extremity were normal.

Motor functions: the FRT test demonstrated failed dynamic balance on the left and the NPHT test showed damaged fine motoric. In the TMF test deceleration of performance was identified in all tests performed by the left hand and by both upper limbs and the trial moreover evidenced deceleration of performance in subtests concerning composition and decomposition of the objects called "Pyramid" and "Mummy". The examination at common daily activities by means of Barthel's index: 100 points.

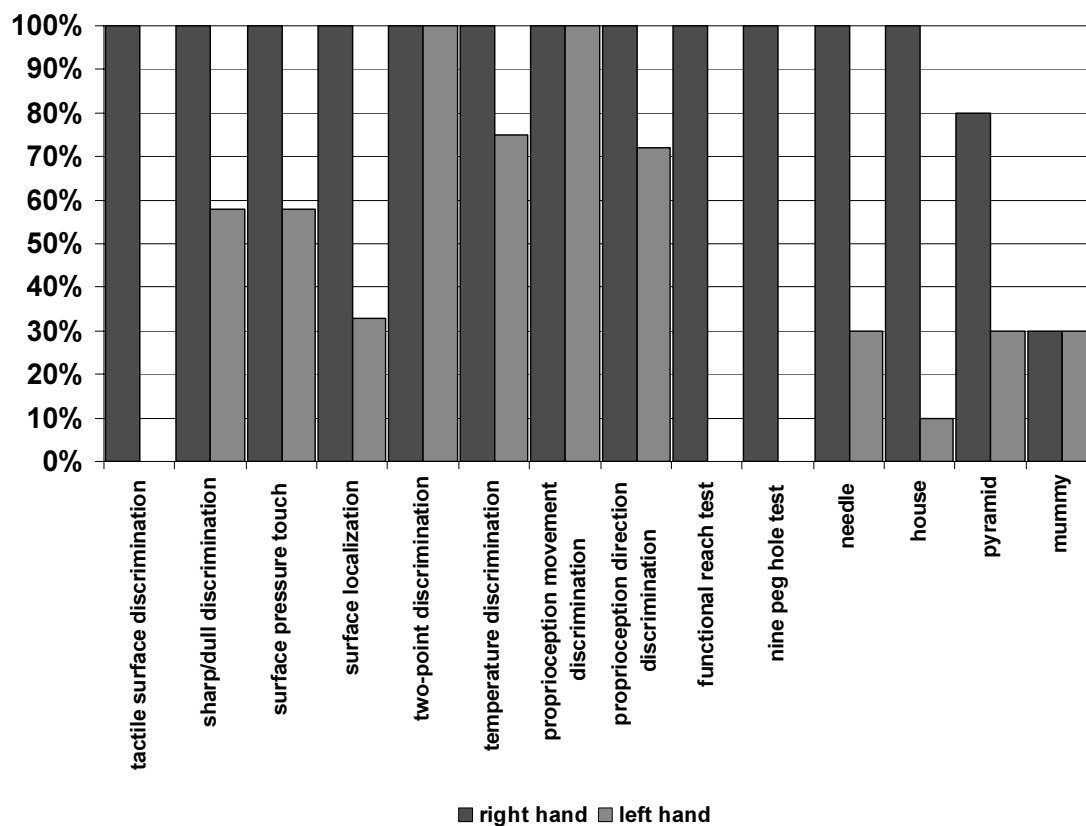
TABLE 4

Examination and assessment of sensorimotor functions of upper extremities by means of selected scales, tests and trials

Examination	Modality	Right upper limb	Left upper limb	Assessment
NIH SS				3
Mingazzini		norm/standard	norm/standard	norm/standard
Ashworth		0	0	norm/standard
FMT	tactile surface discrimination	norm/standard	0 – total loss	anesthesia of the left upper limb
RASP	sharp/dull discrimination	norm/standard	58%	hypo-aesthesia more on the left
	surface pressure touch	norm/standard	58%	hypo-aesthesia more on the left
	surface localization	norm/standard	33%	hypo-aesthesia bilaterally
	two-point discrimination	norm/standard	norm/standard	norm/standard
	temperature discrimination	norm/standard	75%	hypo-aesthesia bilaterally
	proprioception movement discrimination	norm/standard	norm/standard	norm/standard
	proprioception direction discrimination	norm/standard	72%	damaged
FRT	dynamical balance	norm/standard	decreased effort	decreased effort in the left upper limb
NPHT	fine motorics	norm/standard	over 30s	damaged on the left
TMF	manipulating functions – needle	norm/standard	norm/standard	co-ordination of upper limbs stagnates
	house	norm/standard	deceleration of effort	grip lift by the left stagnates
	spire	deceleration of effort	distinctive deceleration of effort	coordination of upper limbs stagnates
	mummy	deceleration of effort	deceleration of effort	deceleration of composition

Diagram 3

Sensorimotor hand function tests

**Fig. 3**

The assessment of the ability to match fabrics; assessed via the manipulating hand function test (TMF - Needle)

a)



b)

**Legend**

On the left photo the patient's task is to find a shape of the same surface as the control shape without looking (on the photo located utmost on the left). Before performing the task, the patient received verbal instructions, an illustrative example and the possibility to feel the tested surface. On the right photo the same patient while performing one of the TMF subtests - putting the needle through the holes using both hands. The coordination of both hands in bimanual activity is stagnating.

DISCUSSION

In the three case studies we show the differences between the results of estimative neurological examinations and the detailed examination of sensorimotor hand functions through other five tests used in our rehabilitation practice. According to clinical neurological examination, all the above mentioned patients were classified as patients with slight deficit or without neurological motor deficit. However, more extended functional examination revealed various deficits in somatosensory and motor hand functions with impact on performance common and work activities.

In the first patient, a deficit in sensory discrimination and also a motoric defect of the hemiparetic upper limb has been diagnosed. It was evidenced not only by achieving time limits during the motor hand tests but also in the quality of the grasp and in the motorics of the whole upper extremity (Fig. 1). According to the results obtained through Barthel's index the patient was completely self-sufficient in common daily tasks.

In the second patient, a motoric deficit of the hemiparetic upper limb is observed, which is evidenced in a deceleration of performance in the fine motoric test NPHT as well as in performing of the handling tasks in the TMF test using of the set of blocks Ministav (Fig. 2). According to the results obtained through Barthel's index, the patient was completely self-sufficient in common daily tasks.

In the third patient, both a severe deficit of somatosensory functions and the deficit of motoric functions were seen. During more detailed examination it has been found that if the patient can compensate sensory impairment via sight, she is able to manage common activities of daily living without bigger problems. As soon as this possibility is restricted or excepted, severe impairment of motor hand functions occurs, which is manifested in deceleration of fine manual activity, less accuracy and excessive effort (Fig. 3). According to the results obtained through Barthel's index the patient was completely self-sufficient in common daily tasks.

In 1999, the Winward group carried out a project in Great Britain. It's aim was to find out to what extent attention and space is given by three groups of professionals (neurologists, physiotherapists and occupational therapists) to the examination of somatosensory functions into their clinical practice. The clinical neurologists consider testing somatosensory functions to be important within the context of identifying the extent and grade of a stroke. The physiotherapists consider the results of the tests important for planning the treatment and aims of rehabilitation. The occupational therapists claimed that the main reason for assessing somatosensory functions was the education of the patient and his/her career. All three groups agreed that testing so-

matosensory functions generates useful information for the patient's prognosis. They also point out that there are no simple objective nor standardized assessments in clinical practice (Winward et al., 1999).

The choice of tests used during the examination of sensorimotor hand functions should correspond with the planned intervention (therapy) and should be aimed at the patient, i. e. should correspond with the tasks being assessed (e. g. impairment, activity or participation).

The choice of tests depends on economic, material and personnel potentialities of the professional workplaces. The requirements for testing can be changed during the treatment in relation to changes in the patient's condition and to specific defined goals of rehabilitation. Obviously the problem of testing has not been unambiguously solved so far because particular clinical workplaces concerned with this issue are still looking for appropriate sets of tests or they even try to create their own test or their set of tests. The reasons are on the economic and the actual unavailability of some testing procedures used abroad, poor awareness of their standardization and sometimes also unwillingness to cooperate in workplaces where these patients are hospitalized, during the verification and implementation of the new tests.

CONCLUSIONS

High quality tests should provide valid information on present impairments in examination systems in order to be able to focus on the therapy appropriately. The tests must be based on sensorimotor mechanisms and neurophysiological rules of motor control. This type of approach complies with the evidence based practice rehabilitation. Routine neurological examinations are appropriate for fast primary targeting, interception of apparent disorders, and related impairments of sensorimotor functions. For accurate functional diagnostics it is necessary to use special tests and scales for recording also discrete impairments, to avoid ignoring them or neglecting the possibility of adjustment within the process of rehabilitation. This would also help to make the best use of the patient's potential to remove the motoric function deficit.

We consider the following as to be a basis for effective therapy in disabled sensorimotor hand functions of the stroke patients:

- neurological clinical examinations with more detailed focus on motoric and sensory deficits,
- a more specific rehabilitation examination using valid tests, more accurately revealing the presence of impairments in the field of the sensorimotor system,

- targeted use of methods based on the knowledge of neurophysiological mechanisms of motion control and their combinations,
- cooperation within teams and workplaces treating patients with this diagnoses.

The whole expert team must participate in the sensitive diagnostics of impairments and in the diagnosis of the extent of the deficit. The result of their effort should be preferably a complete and integrated diagnosis that would facilitate the choice of the most efficient therapy and to ensure that it is applied according to the highest standards.

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PORUCHY SENZOMOTORICKÝCH FUNKCÍ RUKY PACIENTŮ PO ISCHEMICKÉ CÉVNÍ MOZKOVÉ PŘÍHODĚ - SROVNÁNÍ VÝSLEDKŮ OBVYKLÉHO KLINICKÉHO VYŠETŘENÍ A VYŠETŘENÍ POMOCÍ STANDARDIZOVANÝCH TESTŮ (PŘÍPADOVÁ STUDIE) (Souhrn anglického textu)

Poruchy senzomotorických funkcí ruky po prodělané cévní mozkové příhodě mají negativní dopad na interakce jedince se zevním prostředím, na provádění běžných denních a pracovních činností a tedy na kvalitu života jako takovou (Carey, 1995). Vzhledem k tomu, že struktura i funkce mozkové kůry jsou schopné modifikace po jejím poškození, hledají se nové postupy terapie, které maximálně podporují plastické změny centrálního nervového systému. Výchozím předpokladem úspěšné terapie je cílené a validní vyšetření všech postižených funkcí ruky diferencovaně i komplexně.

V práci prezentujeme výsledky a zkušenosti z vyšetření hospitalizovaných pacientů po cévní mozkové příhodě. Porušené motorické a somatosenzorické funkce jsme hodnotili pomocí testů somatosenzorických a manipulačních funkcí ruky. Na třech kazuistických případech poukazujeme na rozdíly mezi nálezy klinického neurologického a funkčního vyšetření ruky s použitím cíleně zaměřených speciálních testů.

Klíčová slova: cévní mozková příhoda, hemiparetická ruka, senzomotorické funkce, klinické neurologické vyšetření, funkční testy ruky.

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