Original Article

Stroke Impairment Assessment Set (SIAS) 
—A new evaluation instrument for stroke patients—

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Key words: hemiplegia (片麻痺), impairment (機能障害), functional assessment (機能評価), rehabilitation (リハビリテーション)

Summary

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(Jpn J Rehabil Med 31: 119-125, 1994)

A new method for the evaluation of stroke patients, designated the Stroke Impairment Assessment Set (SIAS) is presented. The SIAS primarily employs single-task assessment of various functions and rates performance on scales of 0 to 5 or 0 to 3. The items evaluated include motor function, muscle tone, sensation, range of motion, pain, trunk control, visuospatial perception, aphasia and functions on the unaffected side. Scores for each item are plotted on a radar chart, so that deficits can be identified at a glance. The inter-observer variation in SIAS scores is acceptable and assessment can be performed as part of a routine clinical examination.

Introduction

Survivors of stroke continue to increase in number. This is particularly so in Japan, and a recent survey by the Ministry of Health and Welfare indicated that about 43% of patients aged 65 years or older who were institutionalized for at least six months had suffered a stroke. And there is no doubt that we have to develop new methods or improve our traditional modalities in order to enable these patients to return to life in their own community. To carry out effective rehabilitation of stroke patients, we initially need to make an accurate evaluation of the level of impairment. Thus, a more scientific regimen is required in rehabilitation medicine and the evaluation and treatment of impairment must be given more attention than the care of disability.

Wade et al. have introduced a method that is primarily evaluating for arm function as well as the other parts of the body. Fugl-Meyer et al. have a method for the evaluation of physical performance in post-stroke hemiplegic patients. However, these methods require sophisticated equipment which is not generally available or the knowledge of reflexes which are not assessed during routine phys-

Received August 19, 1993; accepted November 8, 1993
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Received May 31, 1993; accepted November 8, 1993
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Reference
We recently developed a new evaluation method for stroke patients called the Stroke Impairment Assessment Set (SIAS), and we have found it can be used to evaluate various aspects of impairment in hemiplegics, including motor, sensory, and motion impairment as well as other deficits. We adopted some of the items in our original SIAS from a symposium on “Methodologic Issues in Stroke Outcome Research” conducted by Gresham, Granger, and Basmajian (Buffalo, NY, July 1989).

The purpose of this paper is to present an outline of the SIAS, so that not only the physiatrist but also other health care professionals will be encouraged to improve the evaluation and treatment of stroke patients by focusing on impairment.

### Methods

A functional assessment and rehabilitation regimen should be carefully devised for each patient on the basis of the International Classification of Impairments, Disabilities and Handicaps (ICIDH) which developed by the WHO in 1980.

When evaluating the impairment of a stroke patient, the major items that need to be covered are listed in Table 1.

The SIAS primarily involves single-task assessment of various functions and rates the patient’s performance on a scale (usually 0 to 5 or 0 to 3).

The total SIAS score ranges from 0 (total impairment) to 76 (normal function).

1) **Motor function, upper extremity**

The upper and lower extremities (U/E : L/E) are evaluated separately and proximal and distal function is also examined separately.

In the upper extremity, the knee-mouth test is designed to evaluate proximal function and the finger test is used for distal function. If a patient is able to touch his contralateral knee with his affected hand and bring it back to his mouth, a score of 3 is given. A score of 5 indicates that the patient carries out the knee-mouth test as smoothly as on the unaffected side. When the patient can only lift the hand to the level of the nipple, a score of 2 is given. If there is no muscle contraction noted in the biceps brachii, a score of 0 is given.

Individual finger movements are tested to assess distal function. If the patient can adequately flex and extend each digit, a score of 3 is given, while a score of 5 indicates normal coordination. A score of 2 means that the patient can move each finger, but is unable to extend and flex them completely. A score of 1 is given for gross finger flexion or mass movement, and 0 is assigned for a complete lack of voluntary finger movement.

2) **Motor function, lower extremity**

In evaluating the lower extremities, proximal motor function is tested by hip flexion in the sitting position. A score of 5 indicates that the patient can flex the hip joint as smoothly as on the unaffected side. A score of 3 means the patient can flex the hip so that the foot is completely off the floor, while a score of 2 is given if the foot is barely lifted off the floor. A score of 0 means that no voluntary hip flexion is noted.

The knee extension test is also used to assess proximal motor function in the lower extremity. When the patient is able to extend the knee joint with normal strength and repetition, a score of 5 is given. When the knee joint can be extended against gravity and with some clumsiness, a score of 3 is assigned.

If the patient can contract the knee extensors and lift the heel off the floor but is unable to extend the
knee joint fully, a score of 2 is given. A score of 0 means no contraction of the quadriceps muscles.

Ankle dorsiflexion with the foot on the floor is examined to assess distal motor function. If the patient is able to dorsiflex the ankle and lift the front of the foot away from the floor, a score of 3 is given. A score of 5 means normal muscle strength and foot-tap coordination. If the tibialis anterior muscle shows no contraction, then the score is 0. Score of 4, 2, are assigned for the intervening levels of ability.

When the patient is unable to sit up in a chair because of acute stroke or poor balance, we use manual muscle testing and estimate the functional score.

3) Tone

Muscle tone is evaluated by using both the deep tendon reflexes (DTR’s) and the passive joint resistance of the upper and lower extremities. Deep tendon reflexes are graded as follows: A score of 0 indicates that reflexes (e.g., the biceps and triceps reflexes in the upper limbs and the patellar and Achilles' tendon reflexes in the lower limbs) are all markedly increased and that even finger flexor clonus or ankle clonus is present. When the tendon reflexes are slightly increased, a score of 2 is given. A score of 1 means that these reflexes are moderately exaggerated or alternatively are absent. A score of 3 means normal or symmetrical reflexes when compared to the unaffected side.

To assess muscle tone, a score of 0 is given when the tone is remarkably increased by passive motion. If muscle tone is moderately increased, a score of 1 is given, and the same score applies when tone is diminished. A score of 2 indicates that muscle tone is only slightly increased, while a score of 3 means that the tone is normal.

4) Sensory function

Light touch sensation is checked on the palm of the hand and the dorsum of the foot. A score of 0 means anesthesia and a score of 3 is normal, with evaluation being based on the examiner’s clinical judgement. To assess position sense, the index finger or thumb is used in the upper extremity and the great toe in the lower extremity. When no position change is detected by the patient after the maximum possible motion, a score of 0 is given. A score of 1 means that the patient recognizes movement of the digits but not the correct direction, even at maximal excursion. When the patient can correctly perceive the direction of a moderate excursion, the score is 2. A score of 3 means that the patient can correctly identify the direction of a slight movement.

5) Range of motion (ROM)

Since the shoulder and the ankle are the major joints which most readily develop contractures, these are the target joints to be examined.

When passive shoulder abduction is limited to less than 45 degrees (normally 180 degrees), a score of 0 is given. A score of 1 means that the joint can be abducted from 45 to 90 degrees, and a score of 2 indicates abduction from 90 to 150 degrees. A score of 3 indicates that abduction of the shoulder beyond 150 degrees is possible.

In the case of ankle dorsiflexion, a score of 0 means that passive dorsiflexion (with the knee fully extended) is limited to less than 10 degrees of plantar flexion (–10 degrees of dorsiflexion). When dorsiflexion of the ankle is limited to 0 degree, a score of 1 is allocated. If the ankle moves up from 0 to 10 degrees, the score is graded as 2, and a score of 3 is given when ankle dorsiflexion exceeds 10 degrees.

6) Pain

A score of 0 means that pain is so severe that this interferes with sleep (pain usually affects the shoulder joints, fingers, or other major joints of the body, but this category also includes the thalamic or central pain syndrome). When pain is moderate and does not interfere with sleep, a score of 2 is given. A score of 3 indicates that the patient does not complain of pain. (Pain not arising from a score–related case, e.g., pain due to degenerative arthritis or kidney stones, should be disregarded in this assessment.)

7) Trunk control

To carry out the essential activities of daily living, head and trunk control are of vital importance. Our preliminary study has indicated that head and trunk control are closely correlated with abdominal muscle strength. Vertical balance is also an important element of trunk control, so we evaluate this item in two categories. First, we evaluate
abdominal muscle strength as follows: The patient rests in the 45-degree semireclining position in a wheelchair or high-back chair and is asked to raise the shoulders off the back of the chair and assume a sitting position. If the patient is unable to sit up, the score is 0. A score of 1 indicates that the patient can sit up provided that there is no resistance to the movement. If the patient can come to the sitting position despite pressure on the sternum by the examiner, a score of 2 is given. A score of 3 means that the patient has good strength in the abdominal muscles and is able to sit up against considerable resistance.

Second, in the verticality (sitting in an upright position) test, a score of 0 is given if the patient cannot maintain a sitting position. When a sitting position can only be maintained while tilting to one side and the patient is unable to correct the posture to the erect position, this is scored as 1. A score of 2 indicates that the patient can sit vertically when reminded to do so. If the patient can sit vertically in a normal manner, this is scored as 3.

If the patient is not allowed to assume the upright position because of medical complications, such as an acute post-haemorrhagic stage, impairment of consciousness, or hypotension, a score of 0 is also given.

8) Visuospatial perception

A 50 cm long tape measure is used and the central pointing method is adopted. The patient is asked to touch (with the unaffected thumb and index finger) the mid-portion of a tape held horizontally in front at a distance of about 50 cm. Two trials are allowed and the largest error is used for scoring. If there is more than a 15 cm deviation from the central point, the score is 0. An error between 15 and 5 cm is scored as 1, while a score of 2 indicates an error between 5 and 2 cm. A score of 3 means deviation from the mid-point by less than 2 cm.

9) Aphasia

Both expression and comprehension are evaluated. A score of 0 means that the patient has total or global aphasia. If the patient is moderately or slightly aphasic, a score of 1 or 2 is respectively given. A score of 3 means that there is no evidence of aphasia.

10) Function of the unaffected side

The hemiplegic side is always compared with the unaffected side, so the presence or absence of impairment on this side must also be evaluated. Such impairment may be caused by physiological aging or a premorbid condition.

The strength of the quadriceps muscles of the lower extremity and the grip strength of the upper extremity are determined.

A score of 0 indicates severe quadriceps weakness for the patient’s age (around antigravity strength). If the patient has moderate (grade 4 of the MMT score) or minimal quadriceps weakness, a score of 1 or 2 is respectively given. A score of 3 means normal strength.

Our preliminary study indicated that a normal grip strength is more than 25 kg for both males and females. Therefore, if the grip strength is above this level in two trials, a score of 3 is given. A score of 2 means a strength of 10—25 kg, and a score of 1 is given if a grip strength is less than 10 kg. If the grip strength is zero, a score of 0 is given.

Inter-observer Variability of the SIAS

In order to examine the inter-observer variability of the SIAS, two assessors (ES and SS) used the test on the same day to rate 12 stroke patients (10 men and 2 women aged 52—69 years; mean: 59 years, 7 with right and 5 with left hemiplegics). Six patients had ischaemic stroke and the remaining six had haemorrhagic brain lesions.

The inter-observer variability was assessed using with weighted-kappa statistical analysis. As shown in Table 2, the scores for nine out of 22 items related to motor and communication function ranged from 0.838 to 1.000, and the correspondence was very high. Scores for 6 items related to tendon reflexes and visuospatial function ranged from 0.615 to 0.776, and there was substantial inter-observer agreement. Another six items related to pain and sensory function showed moderate agreement, with scores from 0.474 to 0.538. The remaining one item (quadriceps strength on the unaffected side) showed poor correspondence (score: 0.111). However, all patients in this study were scored as either 2 or 3 for
quadriceps strength and none were graded as 0 or 1. In this case, the analysis indicated only poor reliability
though the percentile correspondence of this item was a fairly high 66%.

Radar Charting System

Another feature of the SIAS is our method of recording the impairment of stroke patients. Scores for each item are plotted as a percentage on a radar chart so that one can identify at a glance which areas of function are impaired or normal.

Fig. 1-a displays a SIAS radar chart for a 73 year-old man who suffered cerebral infarction 26 days prior to testing. This patient had severe impairment of motor function in the upper extremity and moderate impairment of the lower extremity. He also had moderate weakness of the upper and lower extremity on the sound side. His remaining functions were well preserved and at the time of evaluation, he did not complain of pain.

In the follow-up examination at 251 days after the onset of stroke, the motor function had improved from zero to moderate and there was complete recovery of the lower extremity. His trunk muscles and the sound side of the body had also recovered fully. However, he had developed some contractures of the extremities and moderate shoulder pain despite undergoing a rehabilitation program.

Fig. 1-b shows a radar chart for a 59 year-old man who had a cerebrovascular accident 52 days before this evaluation was made. His impairment was so severe on the affected side that only speech, ROM, and function on the sound side were preserved.

At the second SIAS evaluation 187 days after the ictus, he showed some recovery of his visuospatial deficit and reasonable trunk control. However, severe paralysis of his upper and lower extremity persisted and there was a severe sensory deficit. His ROM and muscle tone were somewhat worsened.

As shown by these examples, the patient’s level of impairment can be followed during a rehabilitation program, and the areas and extent of improvement can be easily determined.

Not all of the items need to be plotted on the radar chart. Each clinician has a routine check-up system for stroke patients and can select the appropriate elements of the SIAS according to this system. However, it is advisable to plot the radar chart in the order of recording so that one can properly recognize deficits by reviewing the chart pattern.

Discussion

Since the WHO established the International Classification of Impairments, Disabilities and Handicaps (ICIDH), it has become an international trend, particularly in the field of rehabilitation medicine, to evaluate dysfunction according to this system.

There have been a great number of evaluation methods developed for chronically ill patients focusing on the level of disability and related to the capacity for independent daily living, but hemiplegic patients can carry out most such activities of daily living with the unaffected extremities. Therefore, the functional evaluation of disability by using such methods does not reflect the improvement of paralysis in stroke patients.

Brunnstrom has advocated the assessment of motor recovery as a synergic pattern, but not all hemiplegic patients follow this process of recovery. Fugl-Meyer et al. also used a motor recovery

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<th>Table 2 Inter-observer Variability of the SIAS: Degree of agreement by weighted-kappa (n=12)</th>
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staging system similar to the Brunnstrom method along with assessment of other functions, such as pain, sensation, and range of motion. However, the evaluation items are numerous and the scoring system is too vague for clinical use.

The Frenchay arm test and the Motricity index are designed to evaluate motor function on the basis of hand function or manual muscle testing. However, the hemiplegic patient behaves quite differently in motor testing when compared with patients who have peripheral nerve injuries. In addition, some evaluation methods employ sophisticated procedures and complicated grading systems, and hence do not attract the interest of clinicians other than rehabilitation specialists.

The Canadian neurological scale has recently been introduced and is designed to assess different levels of impairment in stroke patients. However, this system applies mainly to acute stroke patients and does not seem appropriate for assessment during rehabilitation.

The Stroke Impairment Assessment Set (SIAS) presented in this article is an evaluation procedure which can be carried out during an ordinary physical examination, and it can also be done by other allied medical professionals.

To make evaluation simple, the SIAS uses single-task assessment to examine each item. Functional grading is done from zero to five or zero to three according to the traditional clinical scoring method, with the former scale being used for more objective parameters such as motor function and the latter scale being used for rather subjective parameters such as pain and cognition.

Since, the stroke patient undergoing rehabilitation will often be evaluated in the sitting position, the SIAS is designed for examining a patient seated in a wheelchair or in the reclining position and thus is widely applicable. Some examples are the items related to trunk control and abdominal muscle strength. Furthermore, it is accepted that the testing of communication skills and cognitive ability is more accurately performed with the patient in the sitting position rather than lying in bed. However, if the patient is bedridden, the motor function portion of the SIAS can still be estimated by conventional manual muscle testing.

Statistical evaluation of the SIAS showed satisfactory inter-observer agreement for most items, although assessment of the unaffected leg was rather variable, perhaps because of the weighted-kappa analysis that was used. This subject may require for further investigation.

Radar charts of the level of impairment provide a visual method of detecting functional deficits as well as areas of improvement and/or deterioration at a glance. Neurological function will improve spontaneously as well as with therapy, but joint contractures or muscle power on the sound side may sometimes deteriorate over time. The radar chart sensitively reflects such changes of function during follow up.
In conclusion, we believe that the SIAS may improve the assessment of impairment in stroke patients and thus lead to a better outcome of rehabilitation.

References
6) Methodologic issues in stroke outcome research.

Stroke Impairment Assessment Set (SIAS)

脳血管障害による機能障害は多岐にわたっているために、多面的かつ簡便な機能評価法は少ない。ここに提案する Stroke Impairment Assessment Set (SIAS) は日常臨床で用いる理学・神経学的診断法を主体として、機能項目別に単一手技 (single-task assessment) にて評価し、機能段階は 0 点から 3 点、あるいは 5 点法とするものである。評価項目には運動機能、筋緊張、感覚、ROM、痛み、体幹、視空間認知、言語機能、健側肢機能を含む。また、レーダ・チャートにて脳卒中患者的各機能障害の程度を一瞥でとらえることもできる。統計学的に信頼性にも問題がなく、リハビリテーション医療での応用は広いものと考える。