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Correlation between Assessments of Arm and Leg Ideomotor Apraxia in Hemiplegic Stroke Patients

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Abstract. [Purpose] Ideomotor apraxia (IMA) is a disorder characterized by spatial or temporal errors in correctly performing intentional movements and making meaningful gestures. This study was performed to determine whether the arm IMA scores can be used to predict the leg IMA scores using the IMA test for the upper and lower limbs. [Subjects and Methods] Thirty stroke patients that showed complete paralysis of a hemiplegic limb were recruited for this study. All patients were right-handed with no unilateral spatial neglect or severe cognitive impairment. IMA of the upper and lower limbs was assessed by the arm and leg IMA test. Each test has 12 items, which require patients to reproduce movements by imitation immediately after presentation using the limb ipsilateral to the lesion. [Results] The arm IMA test showed a significant correlation with the leg IMA test. The leg IMA score was predicted by the arm IMA score according to a simple regression model that showed a significant coefficient of simple determination. [Conclusion] We found that the score of the arm IMA test is similar to the score of the leg IMA test in hemiplegic stroke patients. The arm IMA test is a good prognostic factor for predicting the relative degree of leg IMA. Furthermore, IMA of the upper limbs may contribute to the motor planning and execution of the movement strategy for the lower limbs.
Key words: Ideomotor apraxia, Limb apraxia, Assessment, Stroke

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INTRODUCTION

Ideomotor apraxia (IMA) is commonly defined as a disorder of learned skilled movement that consists of a deficit in performing gestures in response to verbal commands or imitation[1,2)]. It is most commonly found in stroke patients, but the deficit may also be seen in patients with Parkinson's disease[3)], Alzheimer's disease[4)], cortico-basal degeneration[5)], and Huntington's disease[6)]. Patients with IMA have particular difficulty when asked to demonstrate how to use an object or how to carry out actions involving a single or series of components of movements. IMA is characterized by spatial or temporal errors not accounted for by elementary motor or sensory deficits. The incidence of IMA is 57% in left- and 34% in right-brain damaged patients[7)]. In addition, IMA persists to some extent in 45% of patients of all severities 1 year after stroke onset[8)]. Many previous studies have shown that IMA typically affects both the ipsilesional and contralesional limbs and results in disorders of gesture orientation, joint coordination, motor velocity, and spatial distortion in execution of a motor program, in spite of a global preservation of action-planning ability[9–11)].

IMA is assessed by categorizing a variety of disorders of gesture imitation that are often specified according to the regions of the body that are affected. These assessments generally include the face, or the upper or lower limbs[12,13)]. The assessment of IMA involves specific patterns of apraxic behavior, including the ability to mimic the use of a gesture and imitate it concurrently with a demonstration provided by the examiner[11,12)]. The assessment of the gesture imitation is a significant predictor of questionnaire ratings of dependency given by health care-givers[2,14)]. In other words, IMA has a significant impact on functional outcome. Thus, the assessment of IMA plays a critical role in the diagnostics of apraxia of the limbs, and many clinicians are required to manage and treat IMA. Despite the fact that IMA seems to be one of the more frequent impairments following stroke, its exact prevalence is not known. Moreover, several studies have addressed IMA of stroke patients, but few previous studies have used a test tool which has high reliability and validity in stroke patients[15–17)]. In the current study, we investigated the correlation between the IMA score of the arm and the leg of stroke patients and the predictability of the leg IMA from the arm IMA scores, using the IMA test for the upper and lower limbs.

SUBJECTS AND METHODS

Thirty patients with unilateral, CT-demonstrated, first stroke (16 patients with left hemisphere damage, 14 patients with right hemisphere damage) were recruited for this study. Their lesions consisted of extensive cortical and subcortical structures, located in the frontal cortex, parietotemporal cortex, basal ganglia, thalamus, and so forth. All patients gave their written informed consent to participate in the experiment in accordance with the ethical standards of the Declaration of Helsinki. All patients were right-handed, as verified by a handedness questionnaire using the modified Edinburgh Handedness Inventory[18]. Our exclusion criteria were the presence of: Wallenberg's syndrome, unilateral spatial neglect and hemianopsia, severe aphasia, impairment of cognitive function (below 24 points in the mini-mental status examination), or a previous history of neurologic or psychiatric diseases other than stroke.

The ideomotor apraxia (IMA) test was proposed by Ambrosoni and is based on defective imitation of gestures or mimicry[12]. It is comprised of 24 items, divided into 2 categories (Arm or Leg) each containing 12 items, assessing the reproduction of certain movements by the nonparetic extremities. The arm IMA test assesses the smoothness and correctness of during the performance of specific movements by the upper limb. The 12 items of the arm IMA test are as follows. (1) The arm is raised laterally, perpendicular to the body. The open hand is swept from one side to the other and brought, palm down, into contact with the opposite shoulder. (2) The open palm is slapped against the back of the neck. (3) The open hand placed palm down, under the chin. (4) Saluting. (5) The hand is held like a tube against the mouth, and the subject blows through it. (6) The hand is raised, palm open forward, as for the sign to stop. (7) Make a closed fist, and place it sideways on the table. Open the hand, and slap the palm down on the table. (8) Place a fist on the forehead and then on the mouth. (9) Make a ring with the fingertips and thumb tip together, all touching the forehead. Move the hand out from the forehead, rotating and opening wide as it moves. (10) Cross yourself. (11) Position the hand perpendicular to the body, fingers downwards and hit the forehead three times. (12) Send a kiss, fingertips together in the ring on the mouth, opening the hand wide as it moves out. The leg IMA test assesses the integrity of the movement pattern in skilled performance by the lower limb. The 12 items of the leg IMA test are as follows. (1) Slide leg the forward. (2) Slide leg the backward. (3) Kick forward. (4) Cross the legs whilst seated. (5) Put one foot in front of the other (touching). (6) Pretend to extinguish a cigarette with your foot. (7) Trace a cross on the floor using your foot. (8) Place one foot above the other. (9) Trace an anti-clockwise circle on the floor using your foot. (10) Place the inner side of your foot on the floor. (11) Place your toe then your heel on the floor. (12) Place the external edge of your foot on the floor. The items are scored as pass or fail according to a set of rules derived from previous studies of limb apraxia[13,19]. Passed items are scored 1 and failed items are scored 0. For each test, the total score ranges from 0 to 12 and the cut-off score is determined as 9 or below. The reliability and validity of the arm and leg IMA tests are 0.72 and 0.96[20].

The examinations were performed by a physical therapist with over five years of experience of stroke assessment and treatment. Patients were tested with two tests assessing IMA from the movements of the arm/hand and the leg/foot. Each test comprised 12 items which were measured once by the examiner, with the patient sitting or standing according to whether or not the patient's condition allowed stand. For increasing test accuracy, each patient was measured twice in succession by the same examiner, with a retest the day after the first test, to avoid the possibility of test memorization. For each test, all patients were instructed to use the limb ipsilateral to the lesion, and they were suggested to reproduce the movements by imitation immediately after presentation; no verbal description of the gestures to be performed was given. Each patient was simultaneously assigned a test score by two examiners. Items that were successfully reproduced in any of the three attempts scored 1 and only items that were consistently failed were scored 0. Both examiners and patients were blinded to the results.

Statistical analysis was performed using PWAS, version 18.0 for Windows. Demographic data such as gender, age, etiology, mini-mental status examination, and handedness were analyzed by descriptive statistics. The relationships between the arm IMA and the leg IMA tests were analyzed using Pearson's correlation coefficient. A logistic regression analysis was performed, to determine whether or not apraxia could be predicted through motor outcomes of the upper extremity, with scores of the arm IMA test as the dependent variable (range 0 to 12), and scores of the leg IMA test (range 0 to 12) as independent variables. All measurements are shown as average ± standard deviation and significance was accepted at values of $p<0.05$.

RESULTS

Demographic data for all subjects are shown in Table 1. The arm IMA test showed a significant correlation with the leg IMA test ($p<0.001$)(Table 2). To better understand the relationship between the arm and leg IMA tests, simple logistic regression models were constructed to determine whether the score of the leg IMA test was associated with the score of the arm IMA test. The regression analysis predicted from clinical data is shown in Table 2. It is expressed by the following equation: $y = 4.329 + 0.615 \times$ (y: the score of the leg IMA test, x: the score of the arm IMA test). In this model, a significant coefficient of simple determination (R2) of 0.233 was shown ($p<0.05$). This model indicates that the score of the leg IMA test can be estimated by assessment of the motor scale of the upper limb.

DISCUSSION

In the current study, we investigated the correlation between the arm and leg IMA test scores, and the ability of arm IMA to predict leg IMA in hemiplegic stroke patients. We found that the score of the arm IMA test was similar to the score of the leg IMA test in all patients; the arm IMA test positively correlated with the leg IMA test. Furthermore, the score of the leg IMA test could be estimated from the score of the arm IMA test through a simple regression model. These results suggest that the assessment of IMA in the upper limb is a good prognostic factor for predicting the

Table 1. General characteristics of all the subjects included in this study

	Demographic values
Gender (Male/Female)	19/11
Age	60.43 ± 14.87
Etiology (Hemorrhage/Infarct)	10/20
Affected hemisphere(Right/Left)	16/14
MMSE-K	27.17 ± 2.78
Handedness	94.43 ± 1.1

Mean ± S.D. MMSE-K; Mini-mental status examination for Koreans

Table 2. Simple regression model summary for the upper and lower limbs

	Measurement	Correlation Coefficient
Arm IMA test	11.63 ± 0.56	0.61*
Leg IMA test	11.53 ± 0.89	
		Simple regression analysis
Arm IMA test	Simple R	0.48*
	Simple R^2	0.23*
	Adjusted R^2	0.21*

Mean ± S.D, IMA; ideomotor apraxia, $p<0.05$

existence of apraxic behavior in the lower limb. Thus, the presence of the arm IMA may strongly influence leg IMA in the internal representation of the motor planning system.

Many previous studies have revealed that severities of IMA correlate with accuracy errors, which appear as movements with spatial or temporal inaccuracy[2,11,21)]. However, these are not correlated with content errors, which are shown as loss of action conceptualization in the making of inappropriate movements[2,11,22)]. IMA is characterized by an inability to perform motor planning and execution for the internal representation of the movement strategy. These internal processes are termed the praxis system, and are closely associated with the neural networks of the parietal and premotor areas[9,12)]. The pathophysiologic mechanism of IMA is considered to be damage of the praxis system, which is involved in the representation of gestures in the brain, the characteristic movements of tools, and a brain model of the body and its position in space. The accurate neural processes of the praxis system are related to the movement strategy and are finally transmitted to the primary motor cortex for movement generation[22–24)]. The primary motor cortex plays an important role in executing the precise movements of the upper and lower limbs according to the movement strategy of the praxis system[7,11,12,15)]. Therefore, damage to the praxis system is a likely candidate as a cause of IMA in the arms and legs, by failing to successfully generate a specific motor plan for movement in hemiplegic stroke patients.

Moreover, several previous studies have reported that apraxia of the lower limbs is sometimes regarded as an aspect of gait apraxia[25,26)]. However, leg apraxia is not simply a feature of gait apraxia[27,28)]. Gait apraxia affects the spontaneous performance of a very routine, synergistic action and is a sequel of bilateral, median premotor frontal lesions[29)]. In contrast, IMA affects the translation of the mental representation of a voluntary gesture into a correct motor program, resulting in distorted movements, and is usually associated with unilateral, parietal, often left-sided, lesions[6,12,30)]. Therefore, the leg IMA test is not related to gait patterns in stroke patients, and leg IMA consists of problems in organizing or initiating voluntary leg movements. Moreover, leg apraxia appears to be associated with severe arm IMA in patients with large lesions, and is a sign of general severity of a patient's conditions[21,31)]. In some studies, task demands have been demonstrated to influence the performance of apraxic subjects[25,31)]. The items used in the arm IMA test consist of both meaningful and meaningless items, but most of the items included in the leg IMA tests are meaningless movements. Thus, in the leg IMA test, detections of errors of leg movements would be less than for arm movements, because degrees of freedom in leg movement are fewer than for arm movement.

The main finding from this study is that apraxia in the upper limbs is a predictor of the leg IMA test for detecting apraxia in the lower limbs. Furthermore, a brief imitation test emerged as a strong predictor of frequency of errors in dexterity tasks for function of the upper extremity. This appears to suggest that arm IMA is more likely to be accompanied by leg IMA in hemiplegic stroke patients. Thus, if apraxic behavior is observed in the upper limb, careful assessment as well as therapeutic intervention for apraxia should be initiated in the ipsilateral lower limb. We acknowledge that this study has some limitations, including the small number of patients recruited. Therefore, further studies will be required, regardless of the presence of leg apraxia influencing motor recovery, involving more cases of the upper extremity in stroke patients with an ipsilateral lesion.

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