Comparison of driving cognition on paretic side in drivers following stroke

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Objective: The left and right sides of the brain have different roles. This study investigated the differences in cognitive driving ability between stroke survivors with damage to the left brain and right brain. Therefore, the purpose of this study was to compare the driving cognitive ability of left and right hemispheric drivers following stroke.

Design: Cross-sectional study.

Methods: The Stroke Drivers’ Screening Assessment (SDSA) from the UK was translated to the Korean Stroke Drivers’ Screening Assessment (K-SDSA) to meet the specific traffic environments of Korea. The SDSA is composed of 4 tasks: 1) a dot cancellation task that measures concentration and visuospatial abilities necessary for driving, 2) a directional matrix task to measure spatio-temporal executive function required for driving, 3) a compass matrix task to measure accurate direction determination ability required for driving, and 4) recognition of traffic signs and reasoning ability to understand traffic situation. The SDSA assessment time is about 30 minutes. The K-SDSA was used to compare the cognitive driving abilities between 15 stroke survivors with left and 15 stroke survivors with right brain damage.

Results: There were significant differences between the persons with stroke patients with left brain lesions (right hemiplegia) compared to the persons with stroke with right brain lesions (left hemiplegia) (p<0.05). It was found that the cognitive driving ability of those with right brain damage was lower than that of the group of left brain damage.

Conclusions: This research investigated the driving cognitive ability of persons with stroke. The therapists can use this information as basis for the driving test and training purposes. It could also be used as a basis to understanding if the cognitive ability of not only stroke survivors but also those with brain damage is adequate to actually drive.

Key Words: Cognition, Drive, Hemiplegia

Introduction

Driving is an important contribution to quality of life in which it is considered to be a basic part of everyday life and can be an important means of voluntary participation in social activities and preventing social isolation [1-5]. The essential elements for safe driving are visual perception, cognitive ability, athletic performance, hearing and performance [6]. However, stroke drivers suffer from functional impairments and stroke-related disturbances in their athletic, cognitive, or visual perception skills. This phenomenon is considered to be an important social problem because it can seriously affect the safety of the driver himself/herself as well as other drivers [7,8]. The step-by-step process of driving rehabilitation consists of a clinical assessment, off-road evaluation, on-road driving evaluation, vehicle modification, driver education and training, and total fitting and operation. In this case, the evaluation of clinical cognitive and motor functions required for safe driving should be performed indoors and should be assessed accurately before performing the actual road driving evaluation, which may be dangerous. However, there is a lack of research on evaluations tools to
assess the ability of stroke drivers [5]. Therefore, this study aimed to evaluate the drivers’ cognitive abilities and compare the abilities with left and right hemispheric drivers.

Methods

Subjects

Participants in this study were 30 chronic stroke drivers who had a stroke 6 months ago (15 with left hemiparesis, 15 with right hemiparesis). The selection criteria for the subjects were that they had a Mini Mental State Examination-Korea (MMSE-K) score of 24 or more, had a driver’s license, and had an average of 2 years or more of driving experience prior to the onset of stroke. The subjects are currently assumed to be driving at least twice a week. Prior to participating in the experiment, all participants were informed about the experimental procedures and agreed to participate. This study was approved by the Institutional Review Board of the Daegu Catholic University (IRB No. CUIRB-2016-0109).

Experimental tools and procedures

The Korean Stroke Driver’s Screening Assessment (K-SDSA) was used. This is a cognitive assessment tool that is used for examining the driving competence of stroke drivers, which was developed at the University of Nottingham, UK, and translated into Korean [9]. The SDSA is composed of 4 tasks in total and is measured in the following order: a dot cancellation task that measures concentration and visuospatial abilities necessary for driving, a directional matrix task to measure spatio-temporal executive function required for driving, a compass matrix task to measure accurate direction determination ability required for driving, and recognition of traffic signs and reasoning ability to understanding traffic situation. The SDSA assessment time is about 30 minutes [10,11].

Dot cancellation

In order to assess visual attention and concentration abilities, there are 3 bundles of 3 points, 4 points, and 5 points, totaling up to 625 (25 rows×25 columns) (Figure 1A). Participants must find and mark the 4-point bundle of these dots within a limited time of 15 minutes (900 seconds). Scoring is done by counting the number of ‘x’ made in a group other than a 4-point bundle group, which are the false positives.

Square matrices directions

This is designed to measure the ability to accurately determine the combination of four directions (front, back, left, and right) of a square matrix as a task of measuring spatio-temporal executive functions required for driving.

Figure 1. Four sub-tests of Stroke Drivers’ Screening Assessment. (A) Dot cancellation. (B) Square matrices directions. (C) Square matrices compass. (D) Road sign recognition.
Table 1. General characteristics of participants (N=30)

| Variable                   | Right hemiplegia (n=15) | Left hemiplegia (n=15) |
|----------------------------|-------------------------|------------------------|
| Age (y)                    | 57.93 (9.53)            | 57.00 (10.68)          |
| Gender (Male/Female)       | 7/8                     | 8/7                    |
| Diving experience (y)      | 14.80 (6.53)            | 16.20 (5.99)           |
| Time since onset (y)       | 4.40 (2.82)             | 5.87 (4.64)            |
| MMSE-K (/30)               | 28.73 (1.03)            | 27.33 (1.68)           |

Values are presented as mean (SD) or number only.

MMSE-K: Mini Mental State Examination-Korea.
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Table 2. Comparison of SDSA scores between the right and left hemiplegia groups (N=30)

| Sub-Item                      | Right hemiplegia (n=15) | Left hemiplegia (n=15) | t (p)         |
|-------------------------------|------------------------|------------------------|--------------|
| Dot cancellation              |                        |                        |              |
| Time (s)                      | 423.13 (71.29)         | 522.80 (77.4)          | −3.6 (<0.001*) |
| Error (items)                 | 27.73 (8.13)           | 24.87 (9.33)           | 0.9 (0.38)   |
| Positives (items)             | 0.80 (0.86)            | 0.87 (1.00)            | −0.2 (0.85)  |
| Square matrices directions (items) | 27.53 (2.17)         | 24.00 (4.53)           | 2.72 (0.01*) |
| Square matrices compass (items) | 19.13 (3.87)          | 15.13 (3.42)           | 3.00 (0.01*) |
| Road sign recognition (items) | 8.00 (1.41)            | 7.07 (1.39)            | 1.83 (0.08)  |

Values are presented as mean (SD).
SDSA: Stroke Drivers’ Screening Assessment.
*p<0.05.

Table 3. Comparison of SDSA scores between the right and left hemiplegia groups (N=30)

| Paretic side     | Right hemiplegia (n=15) | Left hemiplegia (n=15) | t (p)         |
|------------------|-------------------------|------------------------|--------------|
|                  | Pass (n=13)              | Fail (n=2)              | Pass-fail (n=15) |              |
|                  | 9.16 (1.94)             | 5.84 (1.17)             | 1.41 (1.43)  |              |
|                  | 8.73 (1.97)             | 7.12 (1.10)             | −0.31 (1.57) | 3.13 (0.04*) |

Values are presented as mean (SD).
SDSA: Stroke Drivers’ Screening Assessment.
*p<0.05.

(p>0.05) (Table 1).

The subjects’ K-SDSA results

As a result of performing the tasks of K-SDSA, the time required for the point clearing task was significantly longer in the left hemiplegic group (p<0.05) than in the right hemiplegic group (Table 2). The direction matrix task and compass matrix task scores were significantly lower in the left hemiplegic group than in the right hemiplegic group (p<0.05). In addition, as a result of the K-SDSA’s detailed task, 13 persons were classified as ‘stroke pass’ in the right hemiplegic group and 2 persons were classified as ‘stroke fail’ and there were 7 persons who were ‘eligible’ and 8 persons who were ‘ineligible’ (Table 3). In the comparison of the scores obtained by subtracting the ineligibility score from the eligible score, that is, the discriminant score, the scores in the left hemiplegic group was significantly lower than the right hemiplegic group (p<0.05) (Table 3).

Discussion

Driving is an activity requiring visual perception ability, athletic ability, and cognitive ability. However, stroke drivers may have limitations in driving due to impaired exercise, cognition, visual perception abilities, and various stroke complications [12]. This is a very important social problem because it can seriously affect the safety of others as well as their own safety. Therefore, the driving of the disabled population requires a detailed and specialized driving ability assessment and rehabilitation program according to the extent and contents of the disability [13].

In order to investigate the difference in driving ability between the right hemiplegia group and the left hemiparesis group, the British SDSA was used for predicting the driver’s cognitive ability of the stroke driver. The results of this study are as follows. MMSE-K, the most commonly used cognitive function test for stroke drivers, can detect cognitive dysfunction in daily life in a short period of time, but it has limitations in evaluating the cognitive function of the driver [14]. The SDSA is a test tool that can distinguish the characteristic cognitive ability necessary driving in a short amount of time of about 30 minutes. The K-SDSA, which is made for the Korean traffic environment, can accurately predict the driving ability of the stroke driver [6].

The purpose of this study was to evaluate the cognitive ability of persons with stroke who are currently driving. The study was conducted on 15 patients with right hemiplegia and 15 patients with left hemiplegia who had driving experience prior to the onset of stroke. The K-SDSA was used to evaluate the cognitive ability of stroke drivers. The results
showed that the left hemiplegic group had lower driving cognitive abilities than the right hemiplegic group. This can be inferred from the fact that the impairment of the spatial perception power of the right brain had an effect on driving cognitive ability [15].

The results of this study can be used as basic data to determine whether the driver’s cognitive abilities are suitable for driving by using K-SDSA prior to resuming actual driving after the onset of stroke. If the driver’s cognitive abilities are inadequate, he or she can participate in a rehabilitation program or a driving simulation program that improves the spatial perception power of the right brain in order to help return to safe driving. As for limitations of this study, the number of subjects were low, and there was a lack of information on the specific areas of brain damage. In future studies, it is necessary to study driving cognitive abilities according to the sites of brain damage.

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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