Original Article

Usefulness of the driveABLE cognitive assessment in predicting the driving risk factor of stroke patients

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Abstract. [Purpose] This study examined the usefulness of the DriveABLE cognitive assessment tool (DCAT) in predicting the driving risk factor of stroke patients, and compared the cognitive and driving functions of two groups discriminated by DCAT. [Subjects and Methods] A total of forty-two stroke patients with a driver's license participated in this study. Two participants with communication problems were excluded. DCAT was used to evaluate the risk potential to the driver, and the subjects were classified into two groups according to the probability of driving risk estimated by the DCAT evaluation. The safe driver group (SDG) and unsafe driver group (USDG) underwent a driving simulator and cognitive function assessments. [Results] The results of the SDG and USDG were compared. The SDG showed higher cognitive function than the USDG. In addition, the SDG showed higher ability than the USDG in most of the tests associated with the driving function (pedal reaction time, average reaction time, centerline crossing, road edge excursion, off-road accidents, collisions). [Conclusion] DCAT is a useful tool for predicting the risk of driving. In addition, it can predict the driving ability of stroke patients related to the cognitive function. Nevertheless, a multi-faceted study of associated with driving and cognitive functions for safe driving will be needed.
Key words: DriveABLE cognitive assessment, Driving, Stroke

INTRODUCTION

Safe driving comprises of complex activities associated with various cognitive, sensory, motor, and physical factors[1]. Cognitive function is the most important factor leading to the implementation of a safe driving model for stroke patients[2, 3]. Stroke patients with cognitive impairments are often not allowed to drive[4, 5]. Disruption of any activity is an important change that impedes the activities of daily living of stroke patients. Because driving is an important means of transportation, many stroke patients who previously drove wish to drive a car again[6–8]. Therefore, a system for evaluating the driving ability of stroke patients is required.

An on-road driving evaluation is the most definitive assessment method[9]. However, an on-road test has problems regarding time, cost, accident risks of a direct assessment; hence, it's difficult to use widely[2]. Cognitive assessment is used as a driving screening tool for stroke patients because of low cost, safety, and high correlation with a driving evalu-

ation[10]. The assessments currently used in clinical settings include the trail making test (TMT), the useful field of view test (UFOV), the mini mental state examination (MMSE), and the reaction time (RT) test[5]. To assess the driving ability of stroke patients, it is important to evaluate the cognitive functions of attention, memory, reaction time, and problem solving. The DriveABLE cognitive assessment tool (DCAT) was developed to assess the cognitive functions related to driving, and has been used to predict the risk potential of a driving evaluation[11]. In addition, a driving simulator can evaluate a subject's ability under virtual driving conditions, and can predict the risk of an on-road test[2, 12].

This study examined the usefulness of DCAT for predicting the driving risk factors of stroke patients, and compared the driving functions of safe drivers and unsafe drivers in a driving simulator test.

SUBJECTS AND METHODS

Forty-four subjects with stroke participated in this study. The study participants were enrolled from inpatients at a rehabilitation-care hospital in Korea. All the subjects provided their written informed consent to participation in this experiment in accordance with the ethical principles of the Declaration of Helsinki. Participants with no visual problems and no history of seizures or epilepsy within the last 6 months were included. Two participants with commu-

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Table 1. General characteristics of the participants (n=42)

Characteristics	SDG (n=11)	USDG (n=31)
Gender (male/female)	8/3	28/3
Age (years)	50.1±10.2	57.3±11.3
Education (pre/middle/high/above)	2/1/1/7	2/7/7/15
After stroke (months)	61.2±58.0	55.9±55.2
Affected side (Right/Left)	6/5	12/19
Type (Infarction/Hemorrhage)	6/5	18/13
Past driving experience (months)	18.9±5.7	15.6±3.4
Probability of driving risk	7.2±9.2	65.1±16.4

SDG: the safe driver group; USDG: the unsafe driver group

Table 2. Comparison of the cognitive and driving functions between SDG and USDG

			SDG (n=11)	USDG (n=31)
Cognitive Function	MMSE	Score	29.55±0.69	23.68±4.86**
	TMT-A	Mean time (second)	35.59±15.88	114.81±103.01**
	TMT-B	Mean time (second)	79.91±225.00	40.26±171.36**
Driving function	Pedal reaction time	Mean time (second)	0.62±0.20	1.54±1.44**
	Average reaction time	Mean time (second)	0.86±0.22	1.65±1.05**
		Numbers (n)	3.36±3.61	4.45±3.33
	Speed exceedance	Mean time (second)	9.69±7.69	15.70±11.31
		Percentage (%)	10.91±14.69	20.34±20.26
		Numbers (n)	1.45±3.86	15.65±18.38*
	Centerline crossing	Mean time (second)	1.08±2.07	3.32±3.37*
		Percentage (%)	0.81±2.29	8.10±10.00*
		Numbers (n)	3.64±4.41	14.74±16.82**
	Road edge excursion	Mean time (second)	1.50±1.22	4.57±2.87**
		Percentage (%)	1.40±1.88	8.97±9.40**
	Off-road accidents	Numbers (n)	0.27±0.65	5.71±12.17*
	Collisions	Numbers (n)	0.36±0.92	3.16±2.67**

SDG: the safe driver group; USDG: the unsafe driver group; MMSE: mini mental state examination; TMT-A: trail making test-type A; TMT-B: trail making test-type B
*p<0.05, **p<0.01

nication problems were excluded, leaving 42 stroke patients with a driver's license in this study. Table 1 lists the clinical and general characteristics of the participants; there were no significant differences between the groups.

This study was carried out in 4 steps. In the first step, DCAT was used to evaluate the risk potential of the driver. In the second step, the subjects were classified into two groups according to the reference probability driving risk (25%) of the DCAT evaluation. In the next step, the safe driver group (SDG) (n=11) and unsafe driver group (USDG) (n=31) underwent driving simulator and cognitive function assessments. In the final step, the evaluation results of the SDG and USDG were compared.

DCAT is an in-office assessment system for screening the risk of a driver. It measures memory, attention, danger judgment, reaction time, and decision-making[11]. The measurement results were encrypted and transmitted to a central computer, DCAT. The data was analyzed to predict the risk of an on-road driving evaluation. The MMSE has

been reported to be associated with driving[12]. The TMT is divided into A or B types, and it measures response time, attention, sequencing, executive function, and visual scanning[5, 12]. The results of these tests were used to evaluate the cognitive function of the participants in this study. The driving simulator used in this study was the STISIM Drive System-M100 (Systems Technology, USA) that provides diverse driving situations, customizable roadway environments and uses an extensive library of roadway objects[13]. The driving simulator consists of a scenario assessment and a pedal reaction time test. The scenario assessment evaluates the driving function, such as the average response time, the speed exceedance, centerline crossing, road edge excursion, off-road accidents, and collisions.

SPSS 18.0 was used for statistical analysis, and the means and standard deviations were calculated. The independent t-test used to assess the differences in the cognitive and driving functions between the SDG and USDG. A p value < 0.05 was considered significant.

RESULTS

As listed in Table 2, all items of the cognition test showed significant differences between the two groups. The SDG showed higher cognitive function than the USDG. The items of driving function showed significant differences between the two groups. The SDG showed better results in most of the tests associated with the driving function (pedal reaction time, average reaction time, centerline crossing, road edge excursion, off-road accidents, and collisions) than the USDG. On the other hand, the speed exceedance value was similar in the two groups.

DISCUSSION

The main purpose of this study was to compare the cognitive and driving functions of two groups discriminated by DCAT. The usefulness of DCAT in predicting the driving risk factor of stroke patients was confirmed by the results of this study. The cognitive functions include attention, memory, reaction time, executive function associated with driving factors. The MMSE evaluates the cognitive functions related to driving[12, 14]. TMT-A can evaluate the reaction time, visual scanning and visual attention. The TMT-B can also evaluate the executive function among the cognitive functions[5, 12, 14].

The SDG and USDG discriminated using DCAT showed significant differences in their MMSE, TMT-A and TMT-B results. These results show that the prediction method of driving risk by DCAT is useful. In addition, the SDG showed higher cognitive function and safer driving function than the USDG. These results suggest that the DCAT is a useful tool for predicting the risk of driving. These results are consistent with a previous study which showed that DCAT can predict the driving ability of stroke patients and is related to their cognitive function[5].

An on-road driving evaluation is the gold-standard assessment method, but it has time and cost issues, and potential accident risks[9, 15]. A driving simulator reproduces the actual driving status, and a safe evaluation is possible[2]. For this reason, this study analyzed driving function using a driving simulator. The SDG showed significantly better results than USDG for pedal reaction time, average reaction time, centerline crossing, road edge excursion, off-road accidents, and collisions. The driver risk classification based on DCAT provided confirmatory evidence. On the other hand, the speed exceedance value was similar in the two groups. This result has been attributed to self-enhancement effects[16–18]. In other words, the SDG, who had relatively good driving skills, drove at a high speed due to psychological changes.

A limitation of this study was that it did not compare the psychosocial factors associated with driving. Therefore, future research using a sufficient sample size will be needed to obtain strong evidence for safe driving factors associated with psychosocial function to clarify the results of this study. In addition, a multi-faceted study of driving and cognitive functions for safe driving will be required.

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