Original Article

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Post-stroke Aphasia as a Prognostic Factor for Cognitive and Functional Changes in Patients With Stroke: Ischemic Versus Hemorrhagic

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Objective To investigate the comprehensive outcomes in aphasic patients, including their cognitive and functional status after ischemic or hemorrhagic stroke. It also aimed to clarify whether aphasia is a prognostic factor for cognitive and functional improvements in stroke patients.

Methods Sixty-seven ischemic or hemorrhagic stroke patients in the subacute stage who had been diagnosed with aphasia using the Korean version of Frenchay Aphasia Screening Test (K-FAST) were included in the study. Forty-six stroke patients without aphasia were used as controls. All patients were examined with the Korean version of the Western Aphasia Battery (K-WAB). Cognitive and functional assessments of the patients including the Korean version of Mini-Mental State Examination (K-MMSE), and the Korean version of Modified Barthel Index (K-MBI) were performed during admission and 4 weeks after the initial assessments.

Results The initial and follow-up total K-MMSE and K-MBI scores were significantly lower in aphasic patients than in non-aphasic controls. The K-WAB scores highly correlated with the total K-MMSE scores at the follow-up stage in all aphasic stroke patients. The K-WAB scores moderately correlated with the follow-up scores of the K-MBI in ischemic stroke patients but not in hemorrhagic stroke patients.

Conclusion Aphasia influences the cognitive and functional status of stroke patients and has a greater impact on cognitive improvement. Aphasia severity can be one of the prognostic factors for cognitive status in aphasic patients with stroke.

Keywords Aphasia, Stroke, Prognosis, Cognitive dysfunction

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INTRODUCTION

Aphasia is one of the most common neurological deficits in stroke patients [1]. Aphasia may increase the risk of complications such as sepsis and pneumonia, and increase the length of hospital stay [2]. Numerous factors related to patient characteristics and stroke itself are known to be associated with the prognosis of aphasia [3]. Particularly, the cognitive and functional status of patients have been found to be closely related to aphasia [4,5].

Stroke is classified into two major types: ischemic stroke (IS) which is caused by vascular occlusion, and hemorrhagic stroke (HS) which is caused by parenchymal or non-parenchymal bleeding. Both IS and HS present with different clinical features. The survival rate of IS patients is higher compared with that of HS patients. Stroke severity is higher in HS than in IS however, HS patients have been shown to have a higher therapeutic response to rehabilitation compared with that of IS patients [6,7]. The major factors that predict the functional outcomes in IS and HS also differ. Previous studies have reported that the risk factors for HS are age, incontinence, and alcohol intake, and the risk factors for IS are dysphagia, atrial fibrillation, diabetes mellitus, and hyperlipidemia [8,9]. It has also been reported that HS occurred in much younger patients than IS [9].

A few studies have compared aphasic symptoms between the two stroke types [10,11]. One study reported that hypertension and older age were closely associated to aphasic symptoms in HS patients than in IS patients [10]. Another study also reported that the stroke type did not affect the prognosis of aphasia [11]. However, no study has compared the cognitive or functional status and outcome between IS and HS even though these might be closely related to the prognosis of aphasia. Therefore, we investigated whether aphasia has different effects on the cognitive and functional outcomes according to the two major stroke types; IS and HS. Furthermore, we clarified whether the severity of aphasia is a prognostic factor for the cognitive and functional outcomes of IS or HS patients.

MATERIALS AND METHODS

Subjects

We conducted a retrospective study of stroke patients who underwent primary management in neurology or neurosurgery and had also underwent comprehensive rehabilitation in rehabilitation medicine. A total of 125 stroke patients in the subacute stage who manifested clinical symptoms of aphasia and had been screened with the Korean version of Frenchay Aphasia Screening Test (K-FAST) were initially reviewed; 58 patients were excluded from the study due to the lack of follow-up records after initial assessment or diagnosis with another neurological disease. A final total of 67 aphasic patients (39 IS and 28 HS patients) were included in this study and analyzed. Forty-six age- and sex-matched patients without aphasia (37 IS and 9 HS patients) were assigned to the control group. The exclusion criteria for the study were patients who presented with other neurological diseases except stroke or presented with structural abnormalities that affected aphasic symptoms. This study was approved by the Dankook University Hospital Institutional Review Board (No. 2018-05-037).

All patients underwent a conventional stroke rehabilitation program. Individual physical and occupational therapy were performed for 30 minutes, twice daily (only once on Saturday) for 6 days in a week. Cognitive therapy was included in the rehabilitation as needed. In addition to the conventional rehabilitation program, all aphasic patients underwent speech therapy for 30 minutes, once daily for 5 days in a week.

Outcome measurements

As a screening tool for aphasia, the K-FAST, which showed a high reliability and validity for stroke patients in a previous study [12] was performed by a speech therapist for all patients during admission to the rehabilitation unit. Patients with symptoms of aphasia were also assessed with the Korean version of Western Aphasia Battery (K-WAB), which consists of four subtests including spontaneous speech production, comprehension, repetition, and naming. The Aphasia Quotient (AQ), which reflects the severity of spoken language deficits in aphasia (on a scale of 0 to 100), was calculated from these subtests. The neurological status of the patients was evaluated using the National Institutes of Health Stroke Scale

(NIHSS). To assess the cognitive function, the Korean version of Mini-Mental State Examination (K-MMSE) was performed on admission to the rehabilitation unit and 4 weeks after the initial assessments. The K-MMSE consists of five subscales, including orientation, registration recall, attention and calculation, language, and complex commands, and is scored within the range of 0 to 30. The functional status was evaluated using the Korean version of Modified Barthel Index (K-MBI), first during admission and on the 4 weeks follow-up after the initial assessments. The K-MBI, which includes self-care and mobility components, has 10 subscales that range from 0 to 100. The self-care component (ranges from 0 to 70) consists of personal hygiene, bathing, feeding, toileting, going up and down stairs, dressing, defecation, and voiding. The mobility component (ranges from 0 to 30) consists of ambulation and bed transfer.

Statistical analysis

Statistical analyses were performed using the Predictive Analytic Software (PASW) Statistics version 24 (IBM Corp, Armonk, NY, USA). The Shapiro-Wilk test was used to reveal the normal distribution of all numerical variables from the basic characteristics (age, Penetration Aspiration Scale, and NIHSS). The Shapiro-Wilk test was also used to reveal the normal distribution of the aphasia (K-FAST and K-WAB), cognitive, and functional assessments (K-MMSE and K-MBI, respectively). To delineate the factors that were mostly associated with aphasia, the initial cognitive and functional assessments including the subscores and total scores of K-MMSE and K-MBI, as well as the total K-FAST score and K-WABAQ scores were analyzed using the factor analysis with varimax rotation and Kaiser normalization. Mann-Whitney U-test was performed to compare the continuous data on basic characteristics, initial or follow-up K-MMSE and K-MBI scores, and the gain of these scores between non-aphasic and aphasic stroke patients. Kruskal-Wallis test was performed to compare the distribution of aphasia types in ischemic and hemorrhagic stroke patients. Wilcoxon rank sum test was performed to compare the initial and follow-up K-MMSE and K-MBI scores in the stroke patients. Fisher exact test was applied to the categorical data on the basic characteristics, and likelihood ratio test was applied to the aphasia types among the ischemic and hemorrhagic stroke patients. Spearman rank correlation

Table 1. Baseline characteristics of subjects

	All stroke			Ischemic stroke			Hemorrhagic stroke			
	Aphasia (n=67)	Control (n=46)	p-value[a]	Aphasia (n=39)	Control (n=37)	p-value[a]	Aphasia (n=28)	Control (n=9)	p-value[a]	p-value[b]
Age (yr)	68.87±11.87	66.24±12.72	0.122	72.44±11.33	68.49±12.27	0.056	63.89±10.94	57.00±10.67	0.073	0.002*
Male (%)	33 (49.25)	29 (63.04)	0.180	25 (64.10)	25 (67.57)	0.812	8 (28.57)	4 (44.44)	0.432	0.006*
Lt. hemisphere (%)	35 (52.24)	19 (41.30)	0.118	25 (64.10)	14 (38.46)	0.038*	10 (47.62)	5 (55.56)	0.234	0.276
DM (%)	16 (23.88)	20 (43.48)	0.040*	12 (30.77)	13 (35.14)	0.808	4 (14.29)	7 (77.78)	0.001*	0.152
Hypertension (%)	39 (58.21)	30 (65.22)	0.556	24 (61.54)	23 (62.16)	1.000	15 (53.57)	7 (77.78)	0.262	0.618
Tracheostomy (%)	10 (14.93)	0 (0.0)	0.005*	1 (2.56)	0 (0)	1.000	9 (32.14)	0 (0)	0.079	0.001*
Pneumonia (%)	16 (23.88)	2 (4.35)	0.007*	6 (15.38)	2 (5.41)	0.265	10 (35.71)	0 (0)	0.079	0.081
Dysphagia	46 (68.66)	17 (36.96)	0.001*	29 (74.36)	17 (45.95)	0.018*	17 (60.71)	0 (0)	0.002*	0.290
PAS	3.90±2.90	4.35±2.89	0.707	3.89±2.87	4.50±2.87	0.548	3.91±2.99	1.00±0	0.261	0.936
Depression (%)	12 (17.91)	3 (6.52)	0.099	8 (20.51)	1 (2.70)	0.029*	4 (14.29)	2 (22.22)	0.620	0.748
Initial NIHSS	11.91±5.98	4.80±3.43	0.000*	3.89±2.87	4.50±2.87	0.000*	12.68±6.33	7.25±3.49	0.031*	0.333

Values are presented as mean±standard deviation or number (%).
DM, diabetes mellitus; PAS, Penetration Aspiration Scale; NIHSS, National Institutes of Health Stroke Scale.
[a]Mann-Whitney U-test or Fisher exact test compared between aphasic patients and non-aphasic controls.
[b]Mann-Whitney U-test or Fisher exact test compared between aphasic patients in ischemic stroke and those in hemorrhagic stroke.
*p<0.05.

analysis was performed to find the relationships between the K-WAB AQ, K-MMSE, and K-MBI scores. Finally, linear regression analysis was performed to elucidate any relationship between the K-WAB AQ scores, K-MMSE, and K-MBI follow-up or gain scores. Numerical data are presented as mean±standard deviations. p-values less than 0.05 were considered to be significant.

RESULTS

Basic characteristics

Aphasic stroke patients showed a higher incidence of medical conditions including tracheostomy, pneumonia, and dysphagia compared with that of non-aphasic stroke patients (Table 1). Aphasic patients also showed a higher NIHSS score than non-aphasic patients during admission. Sex, existence of hypertension, depression, and lesion location did not differ between aphasic and non-aphasic stroke patients (Table 1). It was observed that HS patients with aphasia had a younger age, a higher number of male sex and a higher incidence of tracheostomy compared with that of IS patients with aphasia. In IS patients, left hemispheric lesion and incidence of depression were more prevalent in aphasic patients compared with the prevalence in non-aphasic patients (Table 1).

Types and severity of aphasia

The distribution of aphasia types was different according to the stroke type (p=0.02) (Table 2). Global aphasia was the most common type in IS patients (48.72%). The occurrence of Wernicke's aphasia was relatively higher in HS patients than in IS patients (25% vs. 7.69%, respectively). There were no differences between the subscale and total K-FAST scores and the AQ of K-WAB in both IS and HS groups.

Cognitive and functional outcomes

All of the aphasic patients' initial and follow-up subscale and total scores of K-MMSE were significantly lower than those of the non-aphasic patients, and all subscale and total scores of K-MMSE at follow-up were higher than those at admission in subjects regardless of presence of aphasia (Table 3). When IS and HS patients with aphasia were compared, all initial, follow-up, and gain subscale and total scores of K-MMSE were not different (p>0.05). However, significant improvement of language subscale from admission to follow-up was seen in HS patients, but not in IS patients (gain score: 2.11±2.56 vs.

Table 2. Characteristics of aphasia in aphasic patients with ischemic or hemorrhagic stroke

	Ischemic (n=39)	Hemorrhagic (n=28)	p-value
Aphasia types			
Global	19 (48.72)	8 (28.57)	0.024*
Broca's	1 (2.56)	5 (17.86)	
Wernicke's	3 (7.69)	7 (25.00)	
Transcortical motor	0 (0)	0 (0)	
Transcortical sensory	0 (0)	2 (7.14)	
Transcortical mixed	1 (2.56)	0 (0)	
Conduction	1 (2.56)	0 (0)	
Anomic	14 (35.90)	6 (21.43)	
K-FAST	6.64±7.81	4.21±4.49	0.387
K-WAB			
Spontaneous speech	7.56±6.08	6.64±5.44	0.408
Comprehension	87.21±72.88	87.25±65.35	0.990
Repetition	38.72±40.68	40.68±38.21	0.918
Naming	40.82±37.73	32.75±33.97	0.278
Aphasia quotient	40.79±40.30	36.63±29.16	0.576

Values are presented in numbers (%) or mean±standard deviations.
K-FAST, Korean version of Frenchay Aphasia Screening Test; K-WAB, Korean version of Western Aphasia Battery.
*p<0.05, obtained from Fisher exact test for categorical data or Kruskal-Wallis test for continuous data.

Table 3. Cognitive status and changes in aphasic and non-aphasic patients with ischemic or hemorrhagic stroke

K-MMSE	All stroke			Ischemic stroke			Hemorrhagic stroke			p-value[b)]
	Aphasia (n=67)	Control (n=46)	p-value[a)]	Aphasia (n=39)	Control (n=37)	p-value[a)]	Aphasia (n=28)	Control (n=9)	p-value[a)]	
Orientation										
Initial	2.72±3.30	8.40±1.84	0.000*	3.21±3.72	8.83±1.44	0.000*	2.04±2.52	6.50±2.27	0.001*	0.299
Follow-up	4.02±3.74	9.31±1.09	0.000*	4.21±4.11	9.47±0.93	0.000*	3.75±3.22	8.63±1.51	0.000*	0.672
Gain	1.32±2.54	1.00±1.75	0.772	1.03±2.62	0.77±1.68	0.816	1.71±2.43	1.89±1.83	0.636	0.299
p-value[c)]	0.000*	0.000*		0.014*	0.010*		0.002*	0.017*		
Attention										
Initial	0.60±1.32	2.79±1.75	0.000*	0.79±1.49	3.11±1.71	0.000*	0.32±0.98	1.38±1.19	0.002*	0.137
Follow-up	0.93±1.50	3.29±1.73	0.000*	1.08±1.72	3.44±1.78	0.000*	0.71±1.12	2.63±1.41	0.002*	0.738
Gain	0.33±1.28	0.48±1.44	0.107	0.28±1.36	0.31±1.39	0.120	0.39±1.20	1.11±1.54	0.235	0.165
p-value[c)]	0.049*	0.013*		0.332	0.072		0.070	0.068		
Recall										
Initial	0.46±0.91	1.58±1.22	0.000*	0.56±1.05	1.66±1.21	0.000*	0.32±0.67	1.25±1.28	0.018*	0.518
Follow-up	0.78±1.11	2.17±1.10	0.000*	0.77±1.11	2.32±1.00	0.000*	0.79±1.13	1.50±1.31	0.165	0.948
Gain	0.31±0.94	0.55±1.07	0.544	0.21±0.95	0.63±1.06	0.194	0.46±0.92	0.22±1.09	0.366	0.402
p-value[c)]	0.009*	0.003*		0.186	0.004*		0.015*	0.458		
Language										
Initial	2.73±3.22	7.60±1.64	0.000*	3.13±3.37	7.86±1.61	0.000*	2.18±2.96	6.50±1.31	0.001*	0.238
Follow-up	4.03±3.39	8.025±1.60	0.000*	3.85±3.55	8.15±1.60	0.000*	4.29±3.20	7.50±1.60	0.009*	0.764
Gain	1.30±2.75	0.52±1.42	0.216	0.72±2.77	0.43±1.52	0.706	2.11±2.56	0.89±0.93	0.451	0.050
p-value[c)]	0.000*	0.013*		0.067	0.103		0.001*	0.038*		
Total										
Initial	7.82±8.91	23.28±5.07	0.000*	8.95±9.81	24.22±4.49	0.000*	6.25±7.36	19.44±5.79	0.000*	0.337
Follow-up	11.54±10.02	25.78±4.11	0.000*	11.54±10.88	26.27±3.90	0.000*	11.54±8.88	23.78±4.60	0.000*	0.871
Gain	3.76±6.52	2.50±3.04	0.935	2.63±6.59	2.05±2.89	0.686	5.29±6.23	4.33±3.12	1.000	0.108
p-value[c)]	0.000*	0.000*		0.009*	0.000*		0.000*	0.018*		

Values are presented as mean±standard deviation.
K-MMSE, Korean version of Mini-Mental State Examination.
[a)]Mann-Whitney U-test compared between aphasic patients and non-aphasic controls.
[b)]Mann-Whitney U-test compared between aphasic patients in ischemic stroke and those in hemorrhagic stroke.
[c)]Wilcoxon rank sum test compared between the initial values and follow-up values.
*p<0.05.

0.72±2.77, respectively).

The initial and follow-up subscores and total scores of K-MBI were significantly lower in patients with aphasia than in patients without aphasia, and all subscores and total scores of K-MBI were increased at follow-up when compared to initial scores regardless of presence of aphasia (Table 4). When IS and HS patients with aphasia were compared, initial and follow-up subscores and total scores of K-MBI were higher in IS patients than in HS patients ($p<0.05$).

Relationship between aphasia severity and cognitive and functional outcomes

Correlation analysis revealed significant relationships between the K-WAB scores and all initial total K-MMSE and K-MBI scores in stroke patients with aphasia ($p<0.05$) (Table 5). The AQ significantly correlated with the total K-MMSE and K-MBI scores in IS patients with aphasia during follow-up. However, the AQ did not correlate with the K-MBI in HS patients with aphasia ($p>0.05$).

After performing regression analysis to determine whether aphasia severity during admission could predict the cognitive and functional statuses at 4 weeks after admission, we found that the AQ was linearly related with the follow-up K-MMSE ($r^2=0.5391$, $p<0.05$) (Fig. 1A) and K-MBI ($r^2=0.0947$, $p<0.05$) (Fig. 1B). There was a better relationship between the AQ and the total K-MMSE scores in IS compared with that in HS ($r^2=0.6527$ and 0.3538, respectively; $p<0.05$) (Fig. 1D, 1G). In addition, IS showed a mild linear relationship between the AQ and the total K-MBI score ($r^2=0.158$, $p<0.05$) (Fig. 1E). However, HS did not show any relationship between the AQ and the total K-MBI (Fig. 1H) scores ($p>0.05$).

We also found that the AQ did not relate with changes of the total K-MMSE scores ($p>0.05$) (Fig. 2A) or the total K-MBI scores ($p>0.05$) (Fig. 2B) in all stroke patients with aphasia including IS and HS during the 4-week follow-up period.

DISCUSSION

Most aphasic patients might progress to have chronic communication disability and may even evolve from having one type of aphasia to another as they recover [13]. Therefore, it is critical to have an early and aggressive management of aphasic patients after stroke. Since previous studies have reported that clinical features or prognosis are different between ischemic and hemorrhagic stroke, the characteristics and prognosis of aphasia after stroke were thought to be different between the two types of stroke. In this study, we performed the first-ever quantitative evaluation of the cognitive and functional status in aphasic patients that were divided into the ischemic and hemorrhagic stroke groups. We could directly compare the degree of comprehensive cognitive and functional recovery between the patient groups. We found that the cognitive and functional status during admission to the rehabilitation unit worsened 4 weeks after admission in most aphasic patients compared with that in non-aphasic patients regardless of the stroke type (Tables 3, 4). These results are consistent with previous findings in which aphasia was reported to be closely related to cognition and function although these studies did not analyze aphasia by stroke types [4,5]. Previous studies have also found predictive factors for aphasia recovery in stroke patients [14,15]. However, research for the confirmation of the relationship between aphasia and cognitive and functional status or change is urgently needed. Since aphasia has been reported to delay cognitive or functional improvement in stroke patients [4,16], there is an urgent need to confirm the relationship between aphasia and cognitive and functional status or change. More importantly, data on the recovery patterns in stroke patients with aphasia compared with that in non-aphasic patients can be very useful in determining the treatment duration or cognitive and functional status in aphasic patients at the beginning of a rehabilitation program.

In this study, aphasia seems to be closely related to the cognitive status of stroke patients than the overall functional status (represented as K-MBI scores) (Table 5). In line with this result, previous studies have also reported that language deficits such as comprehension problem did not predict the motor-Functional Independence Measure (FIM) score [4,16]. Although aphasic patients have problems with communication, the severity of aphasia did not have a significant impact on motor function during the 4-week treatment period within the rehabilitation unit. Motor function could be treated by physical and occupational therapists with sufficient nonverbal communication.

We found that most of the subscores and AQ of the K-WAB during follow-up did not correlate with the total K-

Table 4. Functional status and changes in aphasic and non-aphasic patients with ischemic or hemorrhagic stroke

K-MBI	All stroke			Ischemic stroke			Hemorrhagic stroke			p-value[b]
	Aphasia (n=67)	Control (n=46)	p-value[a]	Aphasia (n=39)	Control (n=37)	p-value[a]	Aphasia (n=28)	Control (n=9)	p-value[a]	
Self-care										
Initial	13.91±16.27	38.02±16.27	0.000*	18.90±18.42	38.62±16.52	0.000*	6.96±10.46	35.56±15.88	0.000*	0.003*
Follow-up	28.63±21.56	53.88±13.88	0.000*	34.87±21.89	53.50±13.86	0.000*	19.93±18.07	55.50±14.82	0.000*	0.006*
Gain	14.72±16.12	11.17±19.89	0.736	13.45±12.56	15.33±15.79	0.617	12.96±15.49	17.10±25.24	0.188	0.455
p-value[c]	0.000*	0.000*		0.000*	0.000*		0.000*	0.012*		
Mobility										
Initial	4.78±7.71	12.33±8.63	0.000*	7.10±9.25	13.05±8.82	0.001*	1.54±2.50	9.33±7.52	0.001*	0.002*
Follow-up	10.57±10.01	21.69±7.28	0.000*	13.08±10.76	21.44±6.88	0.000*	7.07±7.77	22.75±9.24	0.000*	0.015*
Gain	5.79±7.13	7.48±9.77	0.195	7.27±8.15	6.10±8.15	0.688	5.54±7.25	11.40±10.22	0.040*	0.721
p-value[c]	0.000*	0.000*		0.000*	0.000*		0.000*	0.012*		
Total										
Initial	18.69±22.82	50.34±23.52	0.000*	26.00±25.84	51.68±23.78	0.000*	8.50±12.19	44.89±22.93	0.000*	0.002*
Follow-up	39.19±30.63	75.57±19.65	0.000*	47.95±31.58	74.86±19.36	0.000*	27.00±25.00	78.44±21.76	0.000*	0.006*
Gain	20.51±21.36	25.22±17.60	0.060	21.95±21.30	23.19±17.86	0.444	18.50±21.68	36.50±16.51	0.023*	0.466
p-value[c]	0.000*	0.000*		0.000*	0.000*		0.000*	0.008*		

Values are presented as mean±standard deviation.
K-MBI, Korean version of Modified Barthel Index.
[a]Mann-Whitney U-test compared between aphasic patients and non-aphasic controls.
[b]Mann-Whitney U-test compared between aphasic patients in ischemic stroke and those in hemorrhagic stroke.
[c]Wilcoxon rank sum test compared between the initial values and follow-up values.
*p<0.05.

Table 5. Correlation analysis between K-WAB scores and cognitive and functional status in stroke patients with aphasia

	All stroke					Ischemic stroke					Hemorrhagic stroke				
	SS	Com	Rep	Nam	AQ	SS	Com	Rep	Nam	AQ	SS	Com	Rep	Nam	AQ
K-MMSE															
Initial	0.753*	0.771*	0.742*	0.771*	0.807*	0.795*	0.861*	0.779*	0.848*	0.849*	0.656*	0.597*	0.662*	0.602*	0.682*
Follow-up	0.652*	0.680*	0.702*	0.726*	0.707*	0.726*	0.749*	0.765*	0.815*	0.761*	0.465*	0.540*	0.592*	0.524*	0.549*
Gain	0.054	-0.004	0.207	0.080	0.059	0.054	-0.014	0.215	0.084	0.040	0.055	0.038	0.199	0.107	0.076
K-MBI															
Initial	0.560*	0.525*	0.436*	0.526*	0.530*	0.575*	0.584*	0.467*	0.579*	0.551*	0.507*	0.542*	0.426*	0.444*	0.523*
Follow-up	0.368*	0.343*	0.339*	0.374*	0.324*	0.407*	0.458*	0.424*	0.466*	0.380*	0.252	0.230*	0.261	0.114	0.231
Gain	0.042	0.002	0.126	0.057	-0.001	0.053	0.035	0.167	0.112	0.004	0.009	-0.034	0.083	-0.126	-0.020

Values are Spearman's correlation coefficients.
K-WAB, Korean version of Western Aphasia Battery; SS, spontaneous speech; Com, comprehension; Rep, repetition; Nam, naming; AQ, Aphasia Quotient; K-MMSE, Korean version of Mini-Mental State Examination; K-MBI, Korean version of Modified Barthel Index.
*p<0.05.

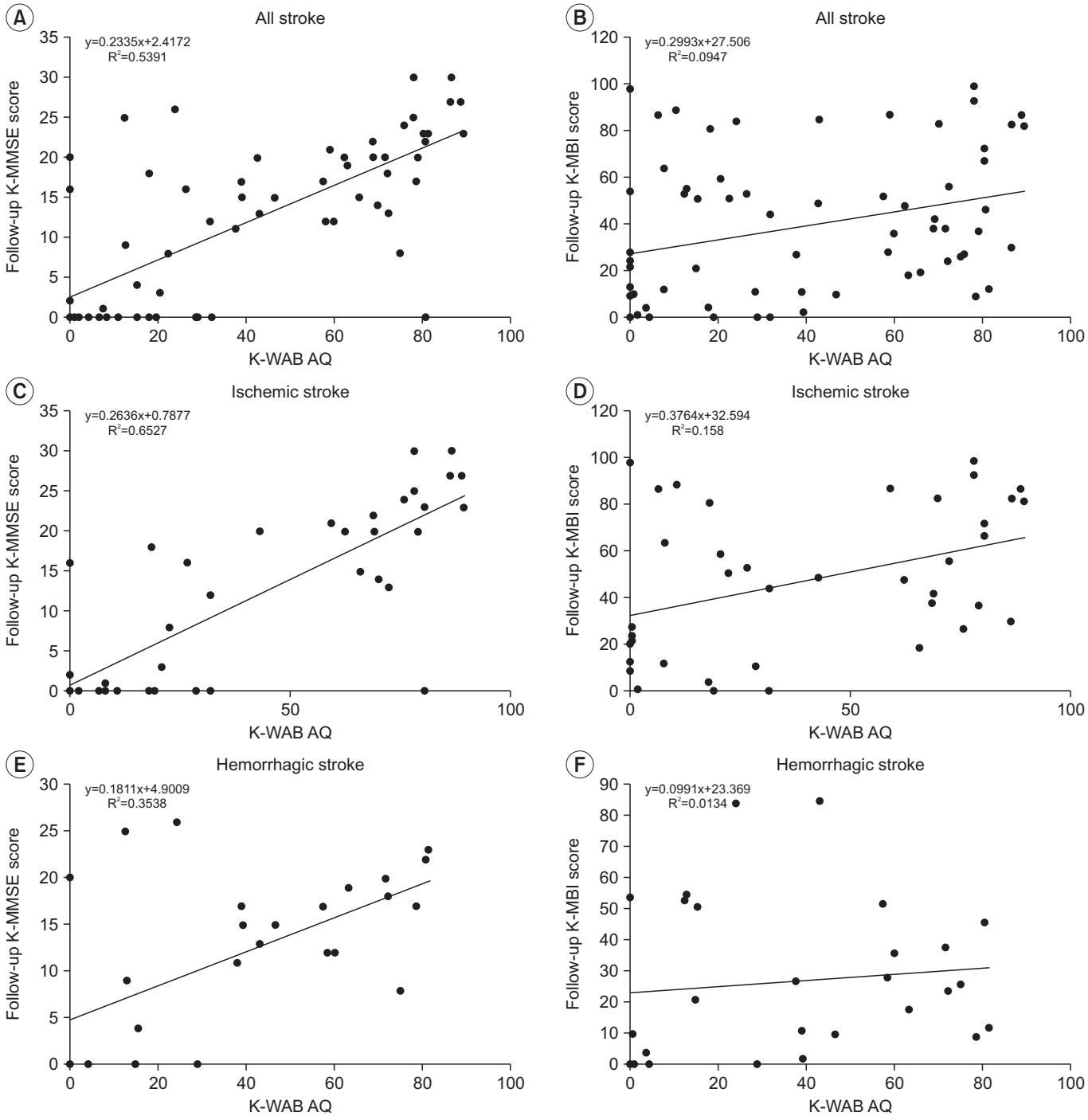

Fig. 1. Regression analysis of (A, C, E) K-MMSE and (B, D, F) K-MBI total scores in all stroke patients with aphasia (A, B), ischemic stroke patients with aphasia (C, D), and hemorrhagic stroke patients with aphasia (E, F) at follow-up according to K-WAB Aphasia Quotient (AQ) at admission. The solid lines indicate regression lines. K-MMSE, Korean version of Mini-Mental State Examination; K-MBI, Korean version of Modified Barthel Index; K-WAB, Korean version of Western Aphasia Battery.

MBI scores in HS patients with aphasia (Table 5). Regression analysis also revealed that AQ did not relate with the total K-MBI and gain scores during follow-up in HS (Figs. 1, 2). The total K-MBI scores was significantly lower in HS patients during follow-up compared with that in IS patients (27.00±25.00 vs. 47.95±31.58; p=0.06) (Table 4).

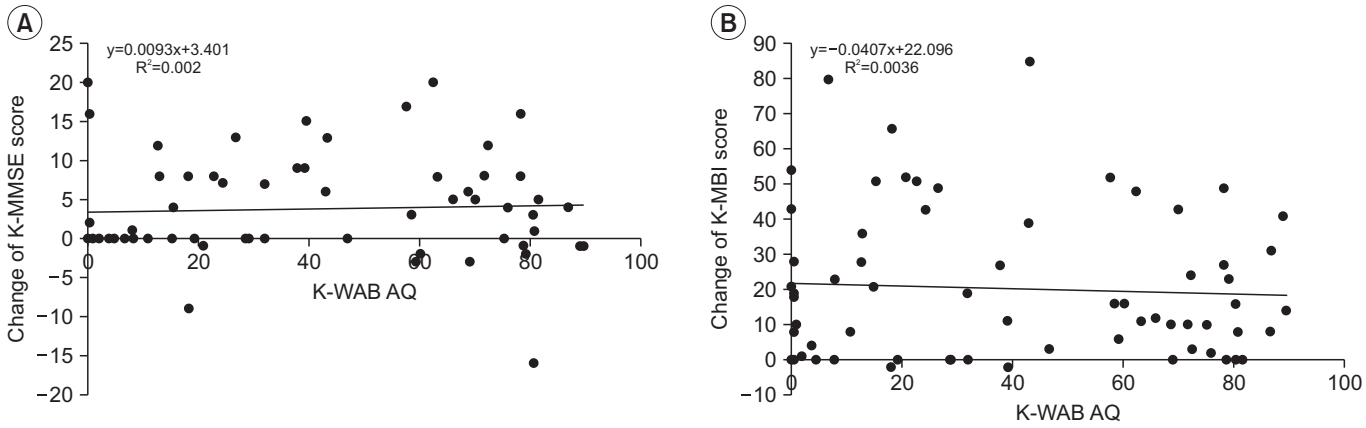

Fig. 2. Regression analysis of (A) K-MMSE, and (B) K-MBI gain scores during follow-up period according to K-WAB Aphasia Quotient (AQ) at admission. The solid lines indicate regression lines. K-MMSE, Korean version of Mini-Mental State Examination; K-MBI, Korean version of Modified Barthel Index; K-WAB, Korean version of Western Aphasia Battery.

However, the AQ was not different between the HS and IS patients (Table 2). Previous studies have reported that the cognitive and functional status of HS patients is more severe compared with that of IS patients [6,7]. One study reported that the treatment of IS patients with tissue plasminogen activator, resulted in better stroke outcomes compared with the outcomes in HS patients. In addition, the study suggested that elevated blood pressure could have influenced the worse prognosis in HS patients [17]. We suggest that the low MBI score may induce floor effect whereby the actual functional changes are not reflected enough to the scoring systems [18,19]. This phenomenon might be common in all aphasic stroke patients with low MBI scores rather than in aphasic patients with hemorrhagic stroke. In addition, it is more difficult to predict the cognitive or functional status by the severity of aphasia alone in these patients. Therefore, further research is needed to find other factors related to the prediction of cognition and function in aphasic patients.

This study has several limitations. First, the follow-up period of 4 weeks is not sufficient to reveal the long-term effects of aphasia on the cognitive and functional changes in stroke patients. Second, we did not consider the aphasic status at follow-up because aphasia recovery was beyond the scope of our study. This study focused on the effect of aphasia (diagnosed at the beginning of rehabilitation management) on cognitive and functional improvement of stroke patients. For the same reason, we did not undertake any in-depth analysis of lesion location or extension and aphasia severity or type. In other words, this study did not focus on the differences in primary lesion and severity of stroke. It rather determined whether there were differences in aphasia type, cognitive function, and functional improvement according to cerebral infarction and cerebral hemorrhage. Third, the MMSE was used to assess cognitive status. This tool is one of the most widely used screening tools but certain items require verbal understanding and answers, which can affect aphasia patients [20]. Thus, further study that utilizes tools to examine both linguistic and nonlinguistic test and tasks such as the Raven's progressive colored matrices [21] is required. In conclusion, aphasia is a predicting factor of the cognitive and functional outcome in stroke patients. This predicting factor differed between IS an HS stroke patients. The IS patients showed stronger correlation between cognitive status and severity of aphasia compared with the correlation in HS patients.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article were reported.

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AUTHOR CONTRIBUTION

Conceptualization: Kim SY, Hyun JK, Seo KC. Methodology: Kim SY, Seo KC, Ko JY. Formal analysis: Kim SY, Hyun JK, Seo KC. Funding acquisition: Kim SY. Project administration: Kim SY, Hyun JK. Visualization: Kim SY, Hyun JK, Seo KC. Writing - original draft: Kim SY, Hyun JK, Seo KC. Writing - review and editing: Kim SY, Hyun JK, Seo KC, Ko JY. Approval of final manuscript: all authors.

REFERENCES

1. Watila MM, Balarabe SA. Factors predicting post-stroke aphasia recovery. J Neurol Sci 2015;352:12-8.
2. Boehme AK, Martin-Schild S, Marshall RS, Lazar RM. Effect of aphasia on acute stroke outcomes. Neurology 2016;87:2348-54.
3. Plowman E, Hentz B, Ellis C Jr. Post-stroke aphasia prognosis: a review of patient-related and stroke-related factors. J Eval Clin Pract 2012;18:689-94.
4. Gialanella B. Aphasia assessment and functional outcome prediction in patients with aphasia after stroke. J Neurol 2011;258:343-9.
5. Fonseca J, Ferreira JJ, Martins IP. Cognitive performance in aphasia due to stroke: a systematic review. Int J Disabil Hum Dev 2017;16:127-39.
6. Andersen KK, Olsen TS, Dehlendorff C, Kammersgaard LP. Hemorrhagic and ischemic strokes compared: stroke severity, mortality, and risk factors. Stroke 2009;40:2068-72.
7. Paolucci S, Antonucci G, Grasso MG, Bragoni M, Coiro P, De Angelis D, et al. Functional outcome of ischemic and hemorrhagic stroke patients after inpatient rehabilitation: a matched comparison. Stroke 2003;34:2861-5.
8. Bhalla A, Wang Y, Rudd A, Wolfe CD. Differences in outcome and predictors between ischemic and intracerebral hemorrhage: the South London Stroke Register. Stroke 2013;44:2174-81.
9. Tsai CF, Jeng JS, Anderson N, Sudlow CL. Comparisons of risk factors for intracerebral hemorrhage versus ischemic stroke in Chinese patients. Neuroepidemiology 2017;48:72-8.
10. Croquelois A, Bogousslavsky J. Stroke aphasia: 1,500 consecutive cases. Cerebrovasc Dis 2011;31:392-9.
11. Klebic J, Salihovic N, Softic R, Salihovic D. Aphasia disorders outcome after stroke. Med Arh 2011;65:283-6.
12. Ha JW, Pyun SB, Lee HY, Hwang YM, Nam K. Reliability and validity analyses of the Korean version of Frenchay Aphasia Screening Test in brain-damaged patients. Commun Sci Disord 2019;14:46-57.
13. Thiel A, Zumbansen A. The pathophysiology of post-stroke aphasia: a network approach. Restor Neurol Neurosci 2016;34:507-18.
14. Tsouli S, Kyritsis AP, Tsagalis G, Virvidaki E, Vemmos KN. Significance of aphasia after first-ever acute stroke: impact on early and late outcomes. Neuroepidemiology 2009;33:96-102.
15. Dickey L, Kagan A, Lindsay MP, Fang J, Rowland A, Black S. Incidence and profile of inpatient stroke-induced aphasia in Ontario, Canada. Arch Phys Med Rehabil 2010;91:196-202.
16. Gialanella B, Bertolinelli M, Lissi M, Prometti P. Predicting outcome after stroke: the role of aphasia. Disabil Rehabil 2011;33:122-9.
17. Chiu D, Peterson L, Elkind MS, Rosand J, Gerber LM, Silverstein M, et al. Comparison of outcomes after intracerebral hemorrhage and ischemic stroke. J Stroke Cerebrovasc Dis 2010;19:225-9.
18. Quinn TJ, Langhorne P, Stott DJ. Barthel index for stroke trials: development, properties, and application. Stroke 2011;42:1146-51.
19. Hsueh IP, Lin JH, Jeng JS, Hsieh CL. Comparison of the psychometric characteristics of the functional independence measure, 5 item Barthel index, and 10 item Barthel index in patients with stroke. J Neurol Neurosurg Psychiatry 2002;73:188-90.
20. Barnay JL, Wauquiez G, Bonnin-Koang HY, Anquetil C, Perennou D, Piscicelli C, et al. Feasibility of the cognitive assessment scale for stroke patients (CASP) vs. MMSE and MoCA in aphasic left hemispheric stroke patients. Ann Phys Rehabil Med 2014;57:422-35.
21. Helm-Estabrooks N. Cognition and aphasia: a discussion and a study. J Commun Disord 2002;35:171-86.