Brief Report

Impact of Bilingualism on Cognitive Outcome After Stroke

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Background and Purpose—Bilingualism has been associated with slower cognitive aging and a later onset of dementia. In this study, we aimed to determine whether bilingualism also influences cognitive outcome after stroke.

Methods—We examined 608 patients with ischemic stroke from a large stroke registry and studied the role of bilingualism in predicting poststroke cognitive impairment in the absence of dementia.

Results—A larger proportion of bilinguals had normal cognition compared with monolinguals (40.5% versus 19.6%; $P<0.0001$), whereas the reverse was noted in patients with cognitive impairment, including vascular dementia and vascular mild cognitive impairment (monolinguals 77.7% versus bilinguals 49.0%; $P<0.0009$). There were no differences in the frequency of aphasia (monolinguals 11.8% versus bilinguals 10.5%; $P=0.354$). Bilingualism was found to be an independent predictor of poststroke cognitive impairment.

Conclusions—Our results suggest that bilingualism leads to a better cognitive outcome after stroke, possibly by enhancing cognitive reserve. **(*Stroke*. 2016;47:00-00. DOI: 10.1161/STROKEAHA.115.010418.)**

Key Words: aphasia ■ dementia, vascular ■ language ■ risk factors ■ stroke

Given the social burden of cognitive impairment caused by cerebrovascular disease,[1] several studies have identified factors that influence cognitive outcome after stroke.[2] A potential protective factor not yet examined in this context is bilingualism. Recent research suggests that bilingualism is associated with better cognitive function in aging[3] and a later onset of dementia, including vascular dementia (VaD).[4] These findings are interpreted in the context of an advantage in executive control and enhanced cognitive reserve in bilinguals.[5] However, this effect is confounded by immigration and education and continues to be debated.[6] To explore this further, we studied the association between bilingualism and cognitive outcome of stroke. We hypothesized that if bilinguals differ from monolinguals in vascular risk factor profile, they would present with a later occurrence of stroke. In contrast, if bilinguals have indeed a better cognitive reserve, we would expect in them the same age of stroke but a more favorable cognitive outcome. Nizam's Institute of Medical Sciences, Hyderabad, is a clinical research center well suited to explore this relationship. Patients with stroke and dementia are assessed by the same team.[7,8] Bilingualism is common, without the confounding effect of immigration, and has been systematically studied.[4]

Methods

Patients

The patients were participants in the Nizam's Institute of Medical Sciences stroke registry, initiated to study clinical profile and outcome in consecutive cases of acute stroke.[7] Records of patients evaluated during 2006 to 2013 were reviewed. Patients with ischemic stroke >18 years and evaluated 3 to 24 months after stroke were included.

Patients with disabling stroke (modified Rankin Scale score>4), severe comorbidities, inadequate data, and preexisting dementia were excluded. The Nizam's Institute of Medical Sciences ethics committee approved the study.

Clinical Evaluation

All patients were evaluated with a detailed history and clinical evaluation by experienced behavioral neurologists, stroke specialists (S.A., S.K., and R.K.), and trained psychologists using a structured diagnostic protocol adapted from the Cambridge Memory Clinic model.[9] Cognitive evaluation was done using Addenbrooke's Cognitive Examination–Revised (ACE-R), a multidimensional cognitive screening tool, adapted for Telugu- and Hindi-speaking populations in Hyderabad. ACE-R has been validated in large studies of stroke outcome.[10] Clinical Dementia Rating scale was used to assess severity of dementia. All patients underwent brain imaging (computed tomographic scan or magnetic resonance imaging). Bilingualism was defined as the ability to communicate in 2 or more languages in interaction with other speakers of these same languages.[4]

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Definition of Outcome Variables

All patients with stroke were classified into the following diagnostic groups: VaD, vascular mild cognitive impairment, aphasia, and strokes with normal cognition. VaD was diagnosed as fulfilling National Institute of Neurological Disorders and Stroke and Association Internationale pour la Recherche et l'Enseignement en Neurosciences (NINDS-AIREN) criteria for possible or probable VaD.[11] Vascular mild cognitive impairment was diagnosed in subjects with impairment in at least 1 cognitive domain subscore of ACE-R, that is, attention, memory, fluency, language, and visuospatial domains, and absence of dementia on clinical interview or Clinical Dementia Rating scale. Impairment in a cognitive domain was defined if the score on the ACE-R subdomain was <2.00 SD below the mean level of age and education-matched norms. Patients with vascular mild cognitive impairment and VaD were considered to have

Table 1. Clinical Characteristics and Cognitive Outcomes of Monolinguals and Bilinguals

	Monolinguals (n=255; 41.9%)	Bilinguals (n=353; 58.1%)	*P* Value
Sociodemographic factors			
Age at examination, yr, mean (SD, range)	56.6 (12.2, 25–89)	57.0 (12.7, 25–92)	0.661
Age at stroke, yr, mean (SD, range)	56.0 (12.3, 23–88.7)	56.5 (12.7, 23–91.7)	0.639
Men	170 (66.7%)	308 (87.3%)	<0.0001*
Literates	164 (64.3%)	328 (92.9%)	<0.0001*
Occupation†			
Elementary	12 (8%)	3 (1%)	<0.0001*
Skilled	128 (85.3%)	195 (67.2%)	
Associate professionals	7 (4.7%)	56 (19.3%)	
Professionals	3 (2%)	36 (12.4%)	
Vascular risk factors			
Hypertension	164 (64.3%)	216 (61.2%)	0.242
Diabetes mellitus	91 (35.7%)	126 (35.7%)	0.534
Cardiac disease	34 (13.3%)	63 (17.8%)	0.082
Smoking ‡	55 (22.8%)	84 (25.0%)	0.308
Chronic alcoholism	63 (26.1%)	84 (25.0%)	0.415
Stroke characteristics			
Duration after stroke, mo	7.2 (6.5, 3–24)	6.8 (6.5, 3–24)	0.467
Laterality of infarct§			
Right	62 (26.7%)	73 (23.2%)	0.116
Left	86 (37.1%)	99 (31.6%)	
Bilateral	84 (36.2%)	141 (45.0%)	
Location of infarct			
Cortical	34 (13.3%)	64 (18.1%)	0.120
Subcortical	162 (63.5%)	215 (60.9%)	
Cortical–subcortical	45 (17.6%)	44 (12.5%)	
Brain stem/cerebellum	14 (5.5%)	30 (8.5%)	
modified Rankin Scale score			
Mild disability (0–2)	191 (74.9%)	256 (72.5%)	0.262
Moderate to severe (3–4)	64 (25.1%)	97 (27.4%)	
Previous stroke	35 (13.7%)	51 (14.4%)	0.448
Family history of dementia¶	5 (2.1%)	12 (3.6%)	0.222
Cognitive outcome			
Normal	50 (19.6%)	143 (40.5%)	<0.0001*
Cognitive impairment (VaMCI+VaD)	175 (77.7%)	173 (49.0%)	0.0009*
Aphasia	30 (11.8%)	37 (10.5%)	0.354

Following Bonferroni correction for 20 multiple regression tests, $P<0.0025$ was considered significant. VaD indicates vascular dementia; and VaMCI, vascular mild cognitive impairment.

*$P<0.0025$.

†Missing data n=67 (housewives n=101 excluded).

‡Missing data n=85.

§Missing data n=63.

¶Missing data n=46.

Table 2. Factors Predicting Poststroke Cognitive Impairment in the Logistic Regression Model

Factor	*P* Value	OR Estimate (95% CI)
Demographic variables		
Age	<0.0001	1.032 (1.015–1.050)*
Bilingualism	0.001	2.184 (1.379–3.458)*
Sex	0.977	0.986 (0.373–2.607)
Education	0.225	1.496 (0.781–2.865)
Occupation	0.881	1.085 (0.369–3.190)
Stroke-related variables		
Left-sided infarcts	0.051	1.511 (0.990–2.304)
Previous stroke	0.030	0.526 (0.295–0.939)
Infarct location	0.199	1.532 (0.799–2.939)
Duration after stroke	0.058	0.974 (0.949–1.001)
Risk factors		
Hypertension	0.014	0.621 (0.424–0.909)*
Chronic alcoholism	0.434	0.815 (0.489–1.360)
Smoking	0.151	0.680 (0.402–1.151)
Cardiac disease	0.787	0.932 (0.560–1.552)
Diabetes mellitus	0.110	0.722 (0.485–1.076)
Family history of dementia	0.063	0.141 (0.018–1.109)
Final regression model		
Bilingualism	<0.001	3.007 (2.032–4.452)*
Age	<0.001	1.026 (1.007–1.039)*
Hypertension	0.056	0.673 (0.457–0.991)

Following Bonferroni correction for 3 multiple regression tests, $P<0.017$ was considered significant. CI indicates confidence interval; and OR, odds ratio.
*$P<0.017$.

poststroke cognitive impairment. Diagnosis of aphasia was made by 2 experienced behavioral neurologists (S.A. and S.K.) and trained psychologists by obtaining a detailed history for language deficits and assessment of language through a clinical interview supported by language subscores of ACE-R. Normal cognitive performance was defined as the absence of impairment on any one of the cognitive domain subscores of ACE-R based on age and education-matched norms. Details of ACE-R adaptation and normative data in local languages are available in Methods section of this article and Tables I and II in the online-only Data Supplement.

Statistical Analysis

Clinical profiles of monolingual and bilingual subjects were compared using independent samples *t* test for continuous variables and χ^2 test for categorical variables. Series of binary logistic regressions were conducted to investigate the effect of relevant variables (enter method in SPSS). The presence of cognitive impairment was the fixed factor for the logistic regression. Statistical analysis was performed using SPSS 20.0 for windows software (SPSS Inc, Chicago, IL), and significance was set at $P<0.05$. Bonferroni-adjusted *P* values were followed to correct for multiple testing issues.

Results

Of the 608 patients, VaD was diagnosed in 189 (31.1%), vascular mild cognitive impairment in 159 (26.2%), aphasia in 67 (11.0%), and 193 (31.7%) were found to be normal. On comparing for poststroke cognitive outcomes, a larger proportion of bilinguals had normal cognition, whereas the reverse was noted in the stroke patients with cognitive impairment (Table 1). There were no differences in the outcome of aphasia between monolinguals and bilinguals. On excluding aphasics, bilinguals had higher scores on total ACE-R and across attention, fluency, and visuospatial domains, but not on memory and language (Table III in the online-only Data Supplement).

To determine factors associated with poststroke cognitive impairment, we compared patients with normal (n=193; 35.7%) and impaired cognition (n=348; 64.3%). Older age, lower educational and occupational status, monolingualism, and vascular risk factors were significant ($P<0.003$; following Bonferroni correction for multiple testing). To study whether bilingualism was independently associated with poststroke cognitive impairment, we performed a series of logistic regressions. There was no colinearity effect among the factors. The first logistic regression incorporated demographic variables, the second included stroke-related variables, and the third examined risk factors. These regression models demonstrated variance of 31%, 24%, and 28%, respectively. Significant variables from the analyses were entered into a final logistic regression analysis. Following a Bonferroni correction, bilingualism and age were found to be significant independent predictors (Table 2).

Discussion

This is the first study examining systematically the relationship between bilingualism and cognitive outcome after stroke. The percentage of patients with intact cognitive functions post stroke was more than twice as high in bilinguals than in monolinguals. In contrast, patients with cognitive impairment were more common in monolinguals. In addition to other well-established factors,[2] bilingualism emerged as an independent predictor of poststroke cognitive impairment. Furthermore, no differences were found between bilinguals and monolinguals in vascular risk factors or in the age at stroke, suggesting that the observed differences are not because of a healthier lifestyle among bilinguals.

The only outcome not influenced by bilingualism was the frequency of aphasia. Although this might look surprising at the first sight, this finding is in-line with current research, suggesting that the mechanism underlying the protective effect of bilingualism is not because of better linguistic but executive functions acquired through a lifelong practice of language switching.[6] The higher scores of bilinguals on attention and fluency domains with no difference in language subscore support this hypothesis. To conclude, our results support the notion of a protective role of bilingualism in the development of poststroke cognitive impairment.

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Disclosures

None.

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The impact of bilingualism on cognitive outcome after stroke

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Table I: Normative data for ACE-R Telugu total and sub-scores according to age (20-39, 40-59, 60-79, 80 and above), and education levels (>12 years, 4-12 years, 0-3 years)

Table II: Normative data for ACE-R Hindi total and sub-scores according to age (20-39, 40-59, 60-79, 80 and above), and education levels (>12 years, 4-12 years, 0-3 years)

Table III: Subtest performance in cognitive subdomains in monolinguals and bilinguals

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Supplemental Methods:

Adaptation of Addenbrooke's Cognitive Examination-Revised (ACE-R) in Telugu and Hindi and normative data

ACE-R is a widely used, concise and easy-to-administer hundred point cognitive assessment tool. It assesses five cognitive domains viz., attention and orientation, memory, fluency, language and visuospatial abilities. This test has a provision for obtaining domain wise composite scores. ACE-R has been used in post-stroke cognitive impairment.[1] The Addenbrooke's Cognitive Examination has been validated in the Indian context in Malayalam,[2] and the revised version ACE-R has been adapted and validated for use in local languages of Hyderabad, for both literate and illiterate populations. The process of adaptation included culturally appropriate modifications of the original English version of ACE-R by examining each item for cultural relevance, translatability, comparable difficulty and adaptability with an aim of tapping the domain identical to the original version. Translations and back translations, and pilot testing were done based on standard procedures.[3] ACE-R was adapted for the illiterate population by modifying literacy dependent items.[4]

Normative data and cut off values in the local languages- Telugu and Hindi were developed by administering the test to healthy controls. Telugu control group subjects consisted 907 literates and 199 illiterates, and Hindi control group subjects consisted 436 literates and 109 illiterates. Mean and SD for total scores and sub-scores in each domain were calculated across 4 age groups (20-39, 40-59, 60-79, 80 and above), and three education levels (>12 years, 4-12 years, 0-3 years), using standard formulae of Mean-2SD. Impairment in cognition was defined if the score on the ACE-R sub-domains was less than 2.00 SD below the mean level of age and education-matched norms. This data has been in use at the memory clinic for diagnosis of dementia, and mild cognitive impairment in previous studies.[5,6]

Table I: Normative data for ACE-R Telugu total and sub-scores according to age (20-39, 40-59, 60-79, 80 and above), and education levels (>12 years, 4-12 years, 0-3 years)

Age Range	Education	N	Total ACE-R (M,SD)	Attention & Orientation (M,SD)	Memory (M,SD)	Fluency (M,SD)	Language (M,SD)	Visuospatial (M,SD)
20-39	Above 12 years	35	97.69 (2.047)	17.89 (0.502)	25.31 (1.091)	13.17 (0.402)	25.86 (0.351)	15.79 (0.291)
	4- 12 years	20	93.88 (2.004)	17.82 (1.01)	23.85 (0.754)	11.15 (0.212)	25.15 (0.987)	15.69 (0.23)
	0-3 years	32	92.56 (1.704)	17.44 (0.726)	24.08 (1.393)	9.56 (0.227)	25.44 (1.13)	15.44 (0.626)
40-59	Above 12 years	247	94.56 (1.632)	17.64 (0.401)	24.55 (1.083)	11.96 (0.513)	24.68 (0.729)	15.65 (0.467)
	4- 12 years	198	94.08 (2.006)	17.51 (0.69)	24.7 (1.299)	11.83 (0.505)	23.02 (0.964)	15.79 (0.465)
	0-3 years	96	91.89 (2.003)	16.97 (1.275)	24.03 (2.021)	11.33 (1.143)	21.35 (0.802)	12.65 (0.846)
60-79	Above 12 years	267	94.01 (2.509)	17.75 (0.685)	24.03 (1.89)	11.75 (1.388)	22.29 (1.294)	15.63 (1.368)
	4- 12 years	93	92.97 (2.398)	17.49 (0.75)	24.28 (1.705)	11.53 (1.346)	22.03 (1.345)	14.76 (1.019)
	0-3 years	51	91.34 (2.595)	16.45 (1.329)	21.28 (1.09)	11.79 (1.544)	20.92 1.034	11.93 1.363
80 and above	Above 12 years	25	95.16 (3.03)	17.77 (0.697)	23.47 (1.677)	11.1 (0.89)	19.92 (1.031)	13.79 (1.035)
	4- 12 years	22	93.18 (3.469)	17.83 (0.943)	23.82 (2.069)	12.71 (1.705)	22.12 (2.11)	12.85 (1.004)
	0-3 years	20	90.27 (3.015)	16.14 (0.926)	21.56 (1.81)	10.41 (1.147)	21.16 (1.97)	11.6 (1.179)

Table II: Normative data for ACE-R Hindi total and sub-scores according to age (20-39, 40-59, 60-79, 80 and above), and education levels (>12 years, 4-12 years, 0-3 years)

Age Range	Education	N	Total ACE-R (M,SD)	Attention & Orientation (M,SD)	Memory (M,SD)	Fluency (M,SD)	Language (M,SD)	Visuospatial (M,SD)
20-39	Above 12 years	40	97.32 (2.032)	17.67 (0.478)	25.26 (1.045)	13.21 (0.415)	25.72 (0.314)	15.65 (0.301)
	4- 12 years	24	94.92 (1.508)	17.91 (0.542)	24.12 (0.568)	12.17 (0.204)	25.65 (0.725)	15.72 (0.451)
	0-3 years	22	92.52 (1.658)	17.56 (0.81)	24.57 (1.263)	10.56 (0.311)	25.31 (0.95)	14.9 (0.762)
40-59	Above 12 years	86	95.28 (1.72)	17.84 (0.413)	24.67 (0.678)	12.15 (0.61)	25.06 (0.427)	15.72 (0.48)
	Upto 12 years	93	94.88 (2.086)	17.62 (0.74)	24.71 (1.378)	11.91 (0.437)	23.78 (0.814)	15.12 (0.478)
	0-3 years	36	91.28 (2.014)	17.13 (1.051)	25.38 (1.98)	11.02 (1.114)	22.64 (0.782)	13.34 (0.564)
60-79	Above 12 years	79	95.38 (2.612)	17.62 (0.714)	24.82 (1.78)	12.38 (1.082)	23.84 (1.163)	15.63 (0.652)
	Upto 12 years	67	93.65 (2.275)	17.82 (1.02)	24.78 (1.782)	11.62 (0.852)	22.68 (1.162)	14.64 (0.764)
	0-3 years	31	91.18 (2.472)	16.25 (1.175)	22.37 (1.12)	11.29 (1.134)	21.14 (1.152)	12.45 (1.083)
80 and above	Above 12 years	23	94.21 (3.07)	17.54 (0.714)	24.28 (1.685)	11.36 (1.023)	22.06 (1.031)	13.52 (0.873)
	Upto 12 years	24	93.32 (3.127)	17.15 (1.021)	24.58 (1.63)	12.18 (1.562)	22.05 (1.34)	13.48 (0.763)
	0-3 years	18	90.12 (2.926)	15.14 (1.056)	22.38 (1.68)	10.13 (0.874)	20.03 (1.563)	11.468 (1.23)

Table III: Subtest performance in cognitive subdomains in monolinguals and bilinguals

	Monolinguals (n=225,41.6%)	Bilinguals (n=316,58.4%)	*P*
ACE-R	72.3 (19.5)	79.1 (17.5)	<0.0001[b]
Attention & Orientation	14.4 (3.6)	16.0 (3.1)	<0.0001[b]
Memory	19.0 (5.5)	20.4 (5.4)	0.011
Fluency	7.0 (3.4)	7.8 (3.5)	0.006[b]
Language	23.2 (4.3)	23.8 (4.2)	0.182
Visuospatial	12.2 (3.9)	13.4 (3.7)	0.001[b]

Following Bonferroni correction for 6 multiple regression tests, p<0.008 was considered a significant P value

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