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Improvement in Aphasia Scores After Stroke Is Well Predicted by Initial Severity

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Background and Purpose—Most improvement from poststroke aphasia occurs within the first 3 months, but there remains unexplained variability in recovery. Recently, we reported a strong correlation between initial impairment and change scores in motor recovery at 90 days. We wanted to determine whether aphasia recovery (defined as a change from baseline to 90 days) shows a comparably strong correlation and whether the relation was similar to that in motor recovery.

Methods—Twenty-one stroke patients had aphasia scores on the Western Aphasia Battery (WAB) obtained on stroke admission ($WAB_{initial}$) and at 90 days ($WAB_{3\ mo}$). The relation between actual change (Δ) scores (defined as $WAB_{3\ mo}-WAB_{initial}$) and $WAB_{initial}$ was calculated in multiple-regression analysis.

Results—Regression analysis demonstrated that $WAB_{initial}$ was highly correlated with ΔWAB ($R^2=0.81$, $P<0.001$) and that, in addition, the relation between $WAB_{initial}$ and ΔWAB was proportional, such that patients recovered 0.73 of maximal potential recovery ($WAB_{maximum}-WAB_{initial}$).

Conclusions—We show that, like motor recovery, there is a highly predictable relation between aphasia recovery and initial impairment, which is also proportional in nature. The comparability of recovery from motor and language impairment suggests that common mechanisms may govern reduction of poststroke neurologic impairment across different functional domains and that they could be the focus of therapeutic intervention. **(*Stroke*. 2010;41:1485-1488.)**

Key Words: aphasia ■ behavioral neurology ■ brain recovery ■ cerebral infarct ■ speech therapy ■ stroke recovery

Most improvement from poststroke aphasia occurs in the first 3 months.[1,2] The factors that account for variability in the degree of recovery during this period, however, remain largely unexplained.[3]

Recently, we found that when motor recovery is defined as a change between initial (baseline) and final impairment levels, initial severity is highly predictive of the magnitude of the change, accounting for almost 90% of the variance.[4] Furthermore, we then found that the relation between the observed change and the maximal potential change (maximum score minus initial score) was proportional, such that patients recovered 70% of their maximal potential recovery. To begin addressing whether such predictable recovery is motor-specific or is a more generalized characteristic of stroke recovery, we applied the same analysis to stroke patients with language deficits.

Subjects and Methods

We used the Performance and Recovery in Stroke (PARIS) database of patients with image-verified, first-time ischemic strokes who underwent serial assessment with impairment measures for hemiparesis, aphasia, and visual neglect.[4,5] Between May 2002 and August 2007, eligible patients screened from the adult, inpatient stroke service as having a new clinical deficit in language, motor, and/or visual spatial function signed an institutional review board–approved informed consent. Individuals with severe comprehension deficits were considered unable to provide consent and could not be enrolled. Initial assessment occurred 24 to 72 hours after stroke onset (mean=2.1 days; SD=1.3); the follow-up examination took place at 90 days (mean=93.1 days; SD=18.8) after the qualifying stroke because it was thought that most spontaneous recovery occurs by this point.[6] The aphasia examination, derived from standardized subtests from the Western Aphasia Battery (WAB),[7] consisted of the evaluation of comprehension ("yes/no questions," "auditory word recognition," "sequential commands"), repetition, and naming ("object naming," "word fluency," "responsive speech") and were chosen because of their high respective intraindividual reliabilities of 88%, 97%, and 92%.[8] Each of the 3 spheres of function yielded a possible score of 10, with a composite perfect score of 30 (WAB_{max}). Initial impairment ($WAB_{initial}$) was defined as a composite score $\leq$28. To determine whether initial aphasia severity predicts change in aphasia scores (achieved $\Delta WAB=[WAB_{3\ mo}-WAB_{initial}]$) and whether the relation is proportional, we performed a regression analysis of aphasia recovery (achieved ΔWAB) with $WAB_{initial}$, age, and lesion volume as independent variables and the change score as the dependent variable. Lesion volume was estimated in cubic centimeters: lesion volume=[product of maximal perpendicular diameters of the diffusion-weighted imaging lesion in cm]×[number of 0.5-cm slices]/2, a reasonably reliable method compared with automated methods.[9] Testing procedures and results for motor function and the methods for the visual-spatial tasks have been described elsewhere.[4,10]

Results

There were 118 patients in the PARIS database during the study period, of whom 21 had aphasia on the baseline PARIS

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Table 1. Patient Demographics and Lesion Locations

Sex	Age, y	Lesion Volume, cm^3	Lesion Location			
			Frontal	Parietal	Temporal	Subcortical
M	76	49.1	X	X		
M	69	35.3	X	X		
F	65	3.4				X*
M	60	8.5		X	X	
M	64	36.7		X	X	
M	57	19.7	X		X	
F	40	26.3				X†
F	60	24.7	X‡	X	X	
M	51	16.1			X§	
M	52	1.0	X			
M	61	1.1			X	
M	81	19.4	X		X	
M	77	1.0		X		
F	27	11.2	X		X	
F	71	21.2	X		X	
M	52	19.1	X		X	
F	57	24.1	X		X	
M	72	47.6	X			
M	65	5.8		X		
F	67	30.2	X¶			
F	24	13.9		X	X	

Lesions designated as those involving the frontal, parietal, and temporal areas always involved cortical regions and in some cases subjacent white-matter areas; subcortical lesions in the rightmost column did not involve the cortex.

*Corona radiata and caudate.

†Thalamic.

‡Includes corona radiata and internal capsule.

§Includes insula.

¶Includes insula and corona radiata.

assessment and had deficits in the mild-to-moderate range to allow them sufficient comprehension to sign consent. Table 1 displays demographic characteristics, lesion locations, and lesion volumes. There were 13 males and 8 females with a mean age of 59.4 years (SD=14.9). All were right-handed with first-time, left hemisphere ischemic strokes. The mean lesion volume was 19.8 cm^3 (SD=13.3): 16 cortical involving the cortex and immediately subjacent white matter, 2 subcortical involving deep gray matter, and 3 mixed cortical and subcortical. (See Table 1 for specific structures involved.) Among the 21 patients, 9 received some form of speech-language therapy after stroke, 8 received no therapy, and we could not ascertain whether language intervention occurred for the remaining 4 patients.

The mean composite aphasia score at baseline ($WAB_{initial}$) was 20.0 (SD=7.7). The mean composite aphasia score at 90 days ($WAB_{3\ mo}$) was 27.5 (SD=3.7). A *t* test for paired samples showed a statistically significant improvement from baseline to follow-up ($P<0.001$). For patients who did not receive speech-language therapy, mean $WAB_{initial}$ was 24.2 (SDS=6.1); for those receiving therapy, the mean $WAB_{initial}$ was 17.7 (SD=5.5), a difference that was statistically significant ($P=0.03$). Within the 3 language spheres at baseline across all patients, the mean naming score was 6.4 (SD=3.5), the mean repetition score was 6.2 (SD=3.7), and the mean comprehension score was 6.9 (SD=3.9), which were not statistically different from each other.

Table 2. Estimated Regression Coefficients for Achieved ΔWAB as the Dependent Variable (N=21)

	Coefficient		*t*	*P*	95% CI for B	
	B	SE			Lower Bound	Upper Bound
y intercept	19.526	3.223	6.058	<0.001	12.726	26.326
$WAB_{initial}$	−0.691	0.087	−7.972	<0.001	−0.873	−0.508
Age	0.010	0.043	0.234	0.818	−0.081	0.101
Lesion volume	0.059	0.048	1.228	0.236	−0.042	0.160

A linear-regression model to predict achieved ΔWAB based on $WAB_{initial}$, lesion volume, and age was highly predictive, with an overall $R^2=0.83$, as shown in Table 2. The regression coefficient was significant for $WAB_{initial}$; the estimated regression coefficients of lesion volume and age, however, were not significant. $WAB_{initial}$ alone accounted for 81% of the variance. That the coefficient for the *y* intercept was near WAB_{max} implied a proportional relation between achieved ΔWAB and potential ΔWAB ($WAB_{max}-WAB_{initial}$), as we previously found for motor recovery[5] (see the Figure), with a *y* intercept near 0.0 and a slope near 1.0. The mean potential ΔWAB was 9.96 (SD=7.6), and the mean achieved ΔWAB was 7.44 (SD=6.2), yielding an overall 0.73 proportional relation. This predictability in recovery held both for those who received speech-language therapy ($R^2=0.76$, $P=0.005$) and those who did not ($R^2=0.90$, $P<0.001$). Among the 3 spheres of language function that were assessed, the mean proportions of recovery were 0.68 (SD=0.29) for naming, 0.70 (SD=0.46) for repetition, and 0.83 (SD=0.25) for comprehension.

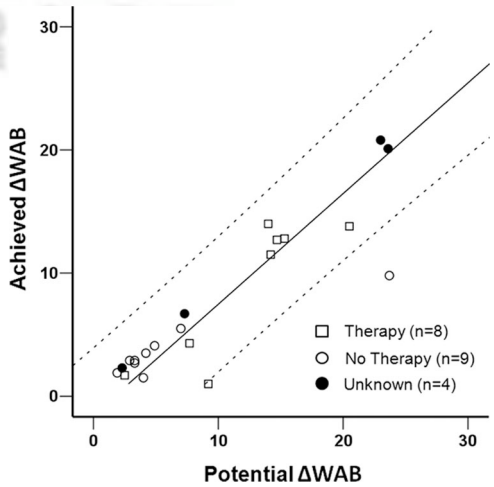

Figure. Relation between the achieved change score on the WAB from baseline to follow-up at 90 days (achieved ΔWAB) and the maximum possible change score (potential ΔWAB) for patients receiving therapy, not receiving therapy, and unknown therapy status. The 95% CIs are displayed above and below. The equation for the curve is $y=1.11x+1.6834$.

Discussion

We found that, among patients with mild to moderate aphasia after acute stroke, recovery, defined as a change between baseline and 90 days, is very well predicted by initial severity. Furthermore, this relation can be expressed as a proportion of the maximal remaining recovery possible. We have reported similar predictability and proportionality (0.7) for recovery from motor impairment.[4] The extension of these previous motor findings to recovery of language suggests that spontaneous recovery may have similar biological mechanisms, related to initial severity, across modalities. The proportionality relation, which need not be present to have a high correlation between initial impairment and recovery, suggests a first-order process, which could be common to stroke recovery from injury, regardless of location. We have recently shown that there is a functional magnetic resonance imaging pattern of brain activation in the first few days after stroke that is correlated with changes in motor function after 90 days but appears to be anatomically independent of contralateral and ipsilateral M1.[11] This finding, in addition to the similarity in predictability of motor and language recovery in the first 90 days after stroke, raises the interesting possibility that multimodal brain areas could influence recovery for both hemiparesis and aphasia.

The high predictability of recovery at the time of acute stroke raises several alternative hypotheses regarding treatment in the first 3 months after stroke. The first, and least likely, is that treatment itself induces the predictable relation, with the therapists providing intervention in direct proportion to impairment. Although it was the case that it was the more impaired patients who received treatment, it would be unlikely that proportionality would be the same for self-recovery in the untreated as it was for the treated (but see interpretation 3). In addition, the same proportional recovery was seen for motor recovery.[4] One would have to posit that therapists have a "0.7" target for both language and motor rehabilitation. The second possibility is that treatment is not having any effect on language recovery. We could not directly address this notion in this study because a direct comparison was not made, nor would we propose the unethical experiment to deny patients therapy. The third possibility, which we believe is most consistent with our data, is that treatment acts to trigger or enable spontaneous, biological recovery mechanisms. If this hypothesis is correct, then the patient who did not receive therapy and whose recovery was an outlier might have achieved an outcome predicted by our model had therapy been given. Thus, our data provide support for the notion that the degree of language recovery at 90 days after stroke is a proportion of the maximum potential improvement in patients with moderate aphasia and who have at least some language therapy. Our findings suggest that if a new therapy is to be considered more effective than current modalities within the initial 90 days after stroke onset, patients who receive it should show a greater change in the WAB composite score than that predicted by the model.

Our findings should not be taken to mean that comprehension, naming, and repetition as assessed herein represent the full range of language functions that can be affected by stroke, exclusive of functions such agrammatism and paragraph-length comprehension. We chose these functions because they (1) are those frequently assessed as elemental components of clinical examinations; (2) have excellent interrater reliability on the WAB; and (3) are sufficiently brief that they could be part of an evaluation battery in our PARIS database that included other neurologic components. Speech fluency was not included because it has among the lowest rates of interobserver agreement,[12] especially by nonspecialist examiners. The rationale for combining them into a single composite measure lies in the matrix in Shewan and Kertesz[8] for subtests on the WAB showing significant correlations among these 3 spheres of language evaluation. These skills do not appear to be functionally independent. Indeed, the internal consistency (coefficient theta) on the overall WAB was 0.97, demonstrating how well the overall WAB score represents its components. Nevertheless, it will be interesting to determine whether other aspects of linguistic function that have low measurement error also demonstrate proportional recovery.

We were unable to address the question regarding recovery from severe aphasia because of consent restrictions imposed by local law. In our previous study of recovery from motor impairment, prediction broke down for patients with severe hemiparesis: some showed proportional recovery but others did not.[4] Whether this occurs for patients with more severe aphasia deficits will have to be addressed in future studies. It would also be interesting, with respect to the question of common mechanisms, to see whether patients who do not recover from severe hemiparesis also do not recover from concomitant severe aphasia, correcting for lesion volume. We also did not have information regarding the type or intensity of therapy. It is possible that any therapy (intense or not) might differentially affect the proportion of recovery, since 8 of 21 did not receive therapy (and we had no information on 4 cases). Furthermore, there might be other therapies that alter the path of natural recovery. Although our method for calculating lesion volumes is considered reliable, there is the possibility that small errors in absolute measurement of small lesions can result in larger measurement error, which could have produced a lack of impact in our regression model. We also recognize that there can be dynamic changes in diffusion-weighted imaging volume after we obtained our images at 24 to 72 hours after onset; decreasing in size because of recovery or reperfusion of the ischemic penumbra or expanding because the penumbra can progress to infarction.[13] Nevertheless, the relation between actual and potential recovery accounted for >80% of the variance, so there was relatively little residual variance that might be accounted for by other factors. Correcting any potential volume measurement errors is therefore unlikely to alter our findings.

In summary, both nonsevere language and motor dysfunctions after stroke seem to show highly predictable recovery during the first 90 days that is related to initial impairment in a very specific way, as a proportion of maximum potential recovery. This similar predictability suggests that there are spontaneous recovery mechanisms operating in the first 3 months that are common to patients with mild to moderate stroke, regardless of domain of dysfunction. These mechanisms, however, might be augmented with biologically fo-

cused intervention early after stroke, perhaps with noninvasive brain stimulation, pharmacology, or targeted behavioral methods to improve function beyond what is currently predicted.

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Disclosures

None.

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