

Early Language Recovery as a Predictor of Functional Outcome in Acute Ischemic Stroke: A Cross-Sectional Study from a Tertiary Care CentreAparna Gaini¹, S. Saravanan²¹Post Graduate, Department of Neurology, TVMCH, Tamil Nadu²Professor and Head, Department of Neurology, TVMCH, Tamil Nadu

Received: 01-06-2025 / Revised: 15-07-2025 / Accepted: 21-08-2025

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Conflict of interest: Nil

Abstract**Background:** Language impairment, particularly aphasia, is a common neuropsychological consequence of left hemispheric stroke. Identifying early predictors of recovery may guide prognosis and rehabilitation strategies.**Objective:** To evaluate whether early language recovery in patients with acute ischemic stroke correlates with functional outcomes at discharge.**Methods:** In this cross-sectional analytical study, 320 patients with acute left hemispheric ischemic stroke were recruited at the Department of Neurology, TVMCH, from June 2023 to July 2024. Language function was assessed on admission and after 7 days using a structured language battery. Improvement was categorized as poor (0–3), intermediate (4–6), or good (>6 points). Functional outcome at discharge was assessed using the Modified Rankin Scale (mRS).**Results:** Among the 320 patients, 112 (35%) had poor, 96 (30%) intermediate, and 112 (35%) good language recovery. Good mRS outcome (0–2) was achieved by 65.2% of patients with good language recovery, versus only 15.2% in the poor recovery group ($p < 0.001$). Early language improvement independently predicted functional outcome in multivariate analysis.**Conclusion:** Early language recovery strongly correlates with better functional outcomes and may serve as a surrogate for ischemic penumbra, particularly in resource-limited settings.

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Introduction

Language impairment is among the most disabling consequences of acute ischemic stroke, particularly when the dominant (typically left) cerebral hemisphere is involved. Aphasia, the most common language disorder in this context, affects nearly one-third of stroke patients in the acute phase, though some studies report even higher prevalence [1,13]. Other language-related deficits such as alexia, agraphia, and acalculia may also occur, further compounding functional disability and impeding recovery.

Aphasia is defined as a disruption in the comprehension or expression of spoken and written language due to acquired brain injury, most commonly resulting from ischemic stroke. The burden of post-stroke aphasia extends beyond communication; it is associated with increased length of hospital stay, poorer functional recovery, higher risk of institutionalization, and greater psychosocial distress for both patients and caregivers. [1,13,15] Neuroimaging studies have shown that language function is closely linked to perfusion status in specific brain regions,

particularly those supplied by the left middle cerebral artery. Perfusion-weighted imaging (PWI) and diffusion-weighted imaging (DWI) together help delineate the ischemic penumbra—tissue that is functionally impaired but potentially salvageable [2,11]. Prior work has demonstrated that the volume of PWI-DWI mismatch correlates more strongly with language deficits than with global stroke severity as measured by traditional scales like the NIH Stroke Scale (NIHSS). [5,7] Moreover, reperfusion of language-related cortical areas has been associated with rapid improvements in aphasia. [11]

Despite these insights, advanced imaging is not universally accessible, particularly in low-resource settings. This has prompted the need for alternative bedside tools to assess recovery potential. Structured language assessments offer a low-cost, non-invasive proxy for evaluating the integrity and recovery of eloquent cortex. Early improvement in language function may indirectly signal reperfusion and restoration of metabolic activity in affected regions, thereby serving as a clinical marker of

salvageable brain tissue. [3,4,9] There is a relative paucity of research correlating early language recovery with global functional outcomes such as those measured by the modified Rankin Scale (mRS) [8,14]. If validated, such a relationship could support the integration of targeted language assessments into early stroke evaluation and prognostication protocols. The present study seeks to bridge this gap by examining whether early recovery of language function during the first week of hospitalization in patients with left hemispheric ischemic stroke is associated with better functional outcome at discharge.

Materials and Methods

Study Design and Setting: This was a hospital-based, cross-sectional analytical study conducted in the Department of Neurology, Thirunelveli Medical College Hospital (TVMCH), a tertiary care referral center. The study duration was from June 2023 to July 2024.

Study Population: Patients aged between 18 and 80 years, presenting with acute ischemic stroke involving the left cerebral hemisphere, confirmed by neuroimaging (CT/MRI), were included. All participants were evaluated within 72 hours of symptom onset and admitted for inpatient management.

Inclusion Criteria

- Age 18–80 years
- Acute ischemic stroke confirmed by CT or MRI
- Left hemispheric infarct (dominant hemisphere for language)
- Able to undergo serial language and neurological assessments

Exclusion Criteria

- Recurrent stroke or transient ischemic attack (TIA)
- Hemorrhagic stroke
- Pre-existing language disorders (due to trauma, tumor, neurodegenerative disease)
- Terminal illness (advanced cardiac, renal, or malignant disease)

Sample Size

The minimum required sample size was calculated using the formula:

$$n = \frac{Z^2 \times P \times (1-P)}{d^2}$$

Assuming a prevalence (P) of early language recovery at 30%, precision (d) of 5%, and confidence level (Z) of 1.96, the sample size was estimated at 320.

Data Collection Procedure

- After obtaining informed consent, eligible patients underwent:
- Detailed clinical and neurological examination
- Stroke severity scoring with NIH Stroke Scale (NIHSS) and Glasgow Coma Scale (GCS)
- Routine investigations (CBC, renal/liver function, lipid profile, ECG, echocardiography, etc.)
- Imaging with CT or MRI including DWI sequences

Language Assessment: Language testing was conducted by a trained neurologist and speech therapist at two timepoints: within 24 hours of admission and on Day 7 post-stroke.

The battery included:

- Oral naming (34 pictures)
- Written naming (34 pictures)
- Tactile naming (17 objects)
- Oral reading (34 real words, 24 pseudowords)
- Spelling to dictation (34 real words, 24 pseudowords)
- Auditory comprehension with semantic, phonological foils and correct targets
- Written word/picture verification with foils
- Repetition of 34 real and 24 pseudowords
- Visual lexical decision (real vs. non-words)
- Auditory lexical decision
- Each item was scored, and cumulative scores were compared between Day 1 and Day 7.

Improvement was categorized as:

- Poor: 0–3 points
- Intermediate: 4–6 points
- Good: >6 points

Functional Outcome: Functional status was assessed at discharge using the Modified Rankin Scale (mRS):

- Good: mRS 0–2
- Moderate: mRS 3–4
- Poor: mRS ≥5

Statistical Analysis: All data were compiled and analyzed using IBM SPSS Statistics software version 25.0. Statistical significance was established at a p-value < 0.05.

1. Descriptive Statistics: Continuous variables such as age, NIHSS score, and language score were presented as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on data distribution (assessed by Shapiro–Wilk test). Categorical variables such as sex, vascular risk factors (e.g., hypertension, diabetes), infarct location, and functional outcome (mRS categories) were expressed as frequencies and percentages.

2. Inferential Statistics

a. Group Comparison

- To compare demographic and clinical variables among the three language recovery groups (Poor, Intermediate, Good):
- One-way ANOVA (or Kruskal–Wallis test for non-parametric data) was used for continuous variables like age, NIHSS score.
- Chi-square test (χ^2) or Fisher's exact test was used for categorical variables (e.g., mRS categories, presence of comorbidities).

b. Correlation Analysis

- Pearson's correlation coefficient (r) was used to assess the strength of association between continuous variables (e.g., language recovery score vs. NIHSS, mRS).
- Spearman's rank correlation was used for ordinal or non-normally distributed variables.

c. Regression Analysis

- To assess whether early language recovery independently predicted favorable functional outcome (mRS 0–2), a binary logistic regression model was constructed:
- The dependent variable was functional outcome at discharge (good vs. poor).

Independent variables included:

- Language recovery category (good/intermediate/poor)
- Age, Sex, NIHSS at admission, Presence of hypertension, diabetes, dyslipidemia, Infarct location (frontal, temporal, parietal), Odds ratios (OR) with 95% confidence intervals (CI) were reported.

d. Receiver Operating Characteristic (ROC) Curve

- An ROC analysis was performed to evaluate the discriminative ability of early language score improvement to predict a favorable mRS outcome. The Area Under the Curve (AUC) was calculated:
- $AUC > 0.8$ was considered excellent predictive value

Summary of Statistical Significance Thresholds:

- $p < 0.05 \rightarrow$ Statistically significant
- $p < 0.01 \rightarrow$ Highly significant
- $p < 0.001 \rightarrow$ Very highly significant

Results

Patient Demographics and Baseline Characteristics

- A total of 320 patients with acute ischemic stroke involving the left hemisphere were

included in the study. The mean age was approximately 62 ± 10 years, with 58% males and 42% females. The most common vascular risk factors were hypertension (72%), diabetes mellitus (48%), dyslipidemia (40%), smoking (35%), and ischemic heart disease (22%).

- The median NIHSS score at admission was 12 (IQR 8–16), and the mean Glasgow Coma Scale (GCS) score was 13.5 ± 1.2 . Infarcts were confirmed by CT or MRI in all cases.

Language Recovery Over First Week

- Language testing was conducted on admission and repeated at 7 days. Improvement in language scores was categorized as follows:
- Poor improvement (0–3 points): 112 patients (35%)
- Intermediate improvement (4–6 points): 96 patients (30%)
- Good improvement (>6 points): 112 patients (35%)
- Patients with good language recovery showed improvements across multiple subdomains, especially in oral naming, auditory comprehension, and repetition tasks.

Functional Outcomes at Discharge

- At discharge, the Modified Rankin Scale (mRS) was used to assess functional outcomes:
- Good outcome (mRS 0–2): 124 patients (39%)
- Moderate outcome (mRS 3–4): 132 patients (41%)
- Poor outcome (mRS 5–6): 64 patients (20%)

Correlation between Language Recovery and Functional Outcome

- A statistically significant association was found between early language recovery and functional status at discharge ($p < 0.001$):
- Among patients with good language recovery, 82% had a good or moderate functional outcome.
- Conversely, among those with poor language recovery, 64% had a poor or moderate outcome, and only 15% achieved a good functional status ($mRS \leq 2$).
- A trend analysis revealed that better language recovery was associated with lower initial NIHSS scores and fewer risk factors, indicating a less severe initial insult.

Predictors of Functional Outcome: Multivariate analysis showed that early language improvement was an independent predictor of good functional outcome (adjusted OR: 3.1, 95% CI: 1.9–5.2, $p < 0.001$), even after adjusting for age, baseline NIHSS, and comorbidities.

Table 1: Baseline and Clinical Characteristics of Study Population

Variable	Value
Total Patients	320
Mean Age (years)	62 ± 10
Male : Female Ratio	186 : 134
Hypertension	230 (72%)
Diabetes Mellitus	154 (48%)
Dyslipidemia	128 (40%)
Smoking	112 (35%)
Ischemic Heart Disease	70 (22%)
Mean NIHSS at admission	12 ± 4.3
Mean GCS at admission	13.5 ± 1.2
Language Recovery – Poor	112 (35%)
Language Recovery – Intermediate	96 (30%)
Language Recovery – Good	112 (35%)
Good Functional Outcome (mRS 0–2)	124 (39%)
Moderate Outcome (mRS 3–4)	132 (41%)
Poor Outcome (mRS ≥5)	64 (20%)

Table 2: Language Recovery Categories

Good (>6 points):	112 patients (35%)
Intermediate (4–6):	96 patients (30%)
Poor (0–3):	112 patients (35%)

Table 3: Functional Outcomes (mRS at Discharge)

Good (mRS 0–2):	124 patients (39%)
Moderate (mRS 3–4):	132 patients (41%)
Poor (mRS ≥5):	64 patients (20%)

Table 4: Correlation between Language Recovery and mRS

Language Recovery	n	Good mRS (0–2)	Moderate (3–4)	Poor (≥5)
Poor (0–3)	112	17 (15.2%)	48 (42.9%)	47 (41.9%)
Intermediate	96	34 (35.4%)	46 (47.9%)	16 (16.7%)
Good (>6)	112	73 (65.2%)	38 (33.9%)	1 (0.9%)

Statistical Significance: Chi-square $p < 0.001$

Multivariate Logistic Regression

- **Predictor:** Good early language recovery
- **Outcome:** Good mRS (0–2)
- **Odds Ratio:** 3.1
- **95% CI:** 1.9–5.2
- **p-value:** < 0.001

The findings suggest that early language recovery within one week of stroke correlates strongly with functional independence at discharge. This supports the hypothesis that language testing may serve as a clinical surrogate for perfusion-based imaging, helping to estimate the extent of salvageable tissue.

Thus, routine language testing in the acute phase may offer valuable prognostic insights, especially in resource-limited settings where advanced imaging is not always available.

Discussion

The present study aimed to evaluate the prognostic significance of early language recovery in patients with acute ischemic stroke involving the dominant

(left) cerebral hemisphere. Our findings indicate a strong and statistically significant association between early improvement in language function and favourable functional outcome at discharge, as measured by the modified Rankin Scale (mRS). These results are consistent with prior research and add new data from a resource-limited setting, reinforcing the clinical value of structured cognitive-linguistic assessments.

Language Recovery as a Predictor of Functional Outcome: Aphasia has been consistently reported as a major determinant of post-stroke disability. In a landmark study by Pedersen et al. (1995), approximately 38% of patients had aphasia in the acute phase, and persistence of language impairment was associated with poorer functional outcomes. Our study further supports these observations, showing that patients with early language improvement (>6 point gain) had a significantly higher likelihood of achieving functional independence (mRS 0–2), compared to those with minimal or no recovery. Hillis et al. (2001) [2,11] demonstrated that perfusion-diffusion

mismatch in left hemisphere strokes, particularly in areas involving Broca's or Wernicke's regions, was closely related to language impairment. In a follow-up study, Hillis et al. [11] (2006) found that reperfusion of left middle cerebral artery (MCA) territory correlated with rapid language improvement. Our findings, although not based on PWI, suggest that early gains in language testing may serve as a behavioral surrogate for reperfusion, offering a practical alternative in settings lacking advanced imaging.

Cognitive Testing vs. NIHSS in Predicting Outcomes: The NIHSS is a widely used stroke severity scale, but its emphasis on motor and visual fields underrepresents cognitive domains, particularly language and executive function. Nys et al. (2005) [5] and Zhang et al. [7] (2019) noted that cognitive assessments—including language testing—correlated more closely with final outcome than NIHSS scores. In our study, NIHSS was recorded, but language test scores provided additional granularity in stratifying patients by recovery potential, reinforcing the need to complement traditional scales with domain-specific testing.

Relevance of Early Language Recovery to Rehabilitation and Prognostication: Early improvement in language reflects not just the extent of infarction but also the potential for cortical reorganization and functional neuroplasticity. Saur et al. (2006) [3] used functional MRI to demonstrate a biphasic pattern of language recovery: early upregulation of contralateral homologs followed by reactivation of perilesional areas. Thus, early behavioral improvement may indicate an optimal neuroplastic response, which, in turn, predicts better overall recovery.

Our findings align with those of Kertesz and McCabe (1977) and Lazar et al. (2008) [4,17], who noted that spontaneous recovery of language within the first 2 weeks post-stroke is a strong predictor of long-term prognosis. In our cohort, language testing on Day 7 allowed for early categorization, enabling clinicians to set realistic goals for rehabilitation and counselling.

Implications for Resource-Limited Settings: Advanced neuroimaging techniques like PWI or arterial spin labeling (ASL) may offer direct visualization of penumbral tissue and predict recovery potential [8,10,14,19]. However, their availability remains limited in many centers, especially in low- and middle-income countries. Our study demonstrates that structured, quantitative language assessment can provide similar prognostic value without the need for high-cost technology [6,12,16,18]. This aligns with the approach proposed by Simmons-Mackie et al. (2007) for

pragmatic, patient-centered aphasia management in real-world clinical practice.

Strengths and Limitations

Strengths of our study include a robust sample size, uniform testing protocol, and real-world applicability. Our use of a comprehensive language battery enabled multidimensional assessment of expressive and receptive functions.

Limitations include:

Lack of long-term follow-up to assess sustained language and functional outcomes.

Absence of imaging correlation with PWI or CT perfusion.

Potential inter-rater variability in language scoring, although minimized by training and standardization.

Conclusion

In conclusion, early language recovery within the first week post-stroke is a reliable and accessible predictor of functional outcome in patients with left hemispheric infarct. Incorporating structured language testing into routine stroke assessment may enhance early prognostication and guide rehabilitation strategies, especially in resource-constrained settings.

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