Original Article

Modified rankin scale is a reliable tool for the rapid assessment of stroke severity and predicting disability outcomes

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Abstract

Background: 'Time is brain' goes the adage. Rapid and precise management of stroke is of the utmost essence. The modified National Institutes of Health Stroke Scale (mNIHSS) and the modified Rankin Scale (mRS) predict stroke severity and functional disability outcomes. However, the mRS can be administered more rapidly than the mNIHSS and therefore might be better to assess patient outcomes. Hence, the aim of this study was to assess the correlation of stroke severity on admission and functional disability outcomes on the day of discharge or on the 8th day of hospitalization. **Materials and Methods:** This was an observational, cross-sectional study with a sample size of 61 participants. The mNIHSS score was calculated on admission for patients with clinical features suggestive of stroke and mRS was calculated on the 8th day of hospitalization or on discharge. Evaluation of the association between continuous variables was done using Spearman's correlation analysis. **Results:** Correlation between mNIHSS and mRS was positive and statistically significant (rho = 0.866, 95% CI [0.751, 0.925]. For each point increase in the mNIHSS, the odds of having higher mRS scores are 153% more than the odds of having lower mRS scores (aOR = 2.534, 95% CI [1.904, 3.560]). **Conclusion:** Our study concluded that mRS can be reliably used to predict the functional outcomes for patients with stroke in circumstances where the mNIHSS may prove to be lengthy. Thus, where 'time is brain', the mRS can be used with a similar power to predict the outcome.

Keywords: Functional outcomes, modified NIHSS, modified Rankin Scale, stroke, stroke prognosis, stroke severity

Introduction

Cerebrovascular accident (CVA) or stroke, a non-communicable disease of high concern, causes high morbidity worldwide and is also the second leading cause of death.[1] Along with a high public health burden of stroke, the burden incurred to afflicted families is fertile soil for loss of employment opportunities, activities of daily living, and psychosocial well-being.[2] Acute ischemic stroke destroys four million neurons per minute.[3] Prompt identification of the severity of stroke and timely intervention are important cogs in the wheel for better patient outcomes.[4,5] For the quantification of stroke severity, the Modified National Institute of Health Stroke Scale (mNIHSS) was developed in 2001 to measure acute neurological deficits in patients recruited in clinical trials and was found to be more reliable than the previously used NIHSS.[6] Subsequently, the modified NIHSS has been extensively used in routine clinical practice to assess the severity and initiate treatment. The Rankin Scale is a measure of global disability and was modified in 1988 to the modified Rankin Scale (mRS).[7] It is extensively validated and is highly reliable for evaluating stroke patients.[8]

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Appropriate counselling and management for stroke patients and their families is necessary to ensure optimal outcomes and reduce disease burden. To achieve this, the mNIHSS and the mRS – tools that assess disease severity and degree of disability respectively – need to be used in consort by healthcare providers. Converging outcomes assessed by these scales would translate to setting realistic expectations from the treatment offered. Moreover, since 'time is brain,' mRS being the faster of the two might be a better option than the mNIHSS to imminently predict patient outcomes.

This study holds significant implications for primary care physicians, who are often the first point of contact for patients experiencing symptoms of a stroke. The practicality of the mRS as a tool is particularly relevant for primary care settings due to its relative ease of use and lesser time requirement for administration compared to the mNIHSS. This simplicity and efficiency in assessing functional disability can be highly beneficial in a primary care context, where time constraints are a common challenge. By understanding the correlations between stroke severity, as assessed by the mNIHSS, and functional disability outcomes measured by the mRS, primary care physicians can play a pivotal role in the early stages of stroke management. Their ability to quickly utilize the mRS for initial assessment and monitoring can lead to informed decisions about timely referrals to specialized care and initiation of appropriate early interventions. Moreover, as family physicians are integral to ongoing patient management and rehabilitation, their ease of use of the mRS scale can enhance their ability to monitor progress, adjust treatment plans, and provide holistic care that addresses both physical and psychosocial aspects of stroke recovery. Thus, the findings of this study are not only crucial for specialized stroke care but also for enriching the stroke management strategies in primary care settings, ultimately contributing to the comprehensive care of stroke patients and potentially improving long-term outcomes.

The primary aim of this study was to assess the correlation of stroke severity on admission by mNIHSS and functional disability outcomes on the day of discharge or on the 8th day of hospitalization as measured by the mRS. Secondary objectives included assessing the predictors for mNIHSS and mRS.

Materials and Methods

Study design and setting

We adopted an observational cross-sectional study design to test our hypothesis. Patients were recruited from the Department of Medicine from the inpatient wards and the intensive care unit (ICU) of a tertiary care hospital in Western India. Our hospital caters to patients from lower socioeconomic backgrounds and provides comprehensive intensive as well as routine care to stroke patients. The study progressed over a four-month period from August 2022 to December 2022. We adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies throughout the study.

Participants

Patients admitted with clinical features suggestive of stroke and were later confirmed with non-contrast computed tomography (CT) or magnetic resonance imaging (MRI) were recruited. We included patients fulfilling the following criteria – patients with symptoms suggestive of stroke, age >18 years, and radiologically confirmed cerebrovascular accident (ischemic/haemorrhagic). Patients with age less than 18 years, patients with known psychiatric disorders, patients with electrolyte disturbances, patients with space occupying lesions in the brain, patients presenting more than 5 days after onset of symptoms and patients not providing consent were excluded.

Data sources/measurement

A written informed consent was obtained from all participants or their relatives on a printed sheet. Demographic data including age, sex, comorbidities including diabetes mellitus and hypertension, duration since symptom onset and radiological findings were collected on a predesigned case sheet. The mNIHSS was calculated at the time of admission using the MDCalc application.[9] The mRS was also calculated using MDCalc on the day of discharge or the 8th day of admission, whichever was earlier. Both of these scores were written in the case sheet.

Clinical diagnosis of stroke

After detailed history and examination of patients reporting to the emergency department or the outpatient department of our hospital, the clinical diagnosis of acute stroke was made using the MONICA (Monitoring trends and determinants of cardiovascular disease) diagnostic criteria.[10]

Modified NIHSS

The mNIHSS quantifies the neurological assessment of patients with stroke and includes the following parameters: consciousness, eye movements, visual field defects, motor impairment in the arms and legs, sensory impairment, aphasia and extinction/inattention/neglect. The mNIHSS overcomes some of the redundancies of the previously used NIHSS. It is used to grade the severity of stroke. The score ranges from 0 to 31; higher the score, more severe is the stroke.[11]

Modified Rankin scale

The mRS is used to measure the degree of dependence or disability in carrying out activities of daily living by patients who have suffered a stroke or other causes of neurological disability. The score ranges from 0 to 6; higher the score, more the disability.[12,13]

Radiological confirmation of stroke

After prompt clinical assessment, the patients were rapidly shifted to the radiology department. Non-contrast computerized tomography and diffusion weighted magnetic resonance imaging scans were done. The diagnosis of stroke was then confirmed with the help of the radiologist's report.

Study size

Sixty-one patients were recruited between August 2022 to December 2022. The estimated power achieved to run a bivariate Pearson's correlation analysis with a two-tailed alpha error rate of 5% to observe a Pearson's product–moment correlation coefficient (r) greater than or equal to 0.4 is calculated to be 90.2%.[14] Power analysis is performed using the 'WebPower' package for R, version 4.2.2.[15]

Statistical methods

Data were summarized as medians (interquartile ranges) for continuous data and as frequencies (percentages) for categorical data. Exploratory data analyses were performed using histograms and boxplots for continuous data.

Evaluation of the association between continuous variables was done using Spearman's correlation analysis. Funder's (2019) recommendations were used to label effect sizes.[16] We used linear and proportional odds logistic regression-based analyses to explain the mNIHSS and mRS scores, respectively.[17]

P values less than 0.05 were considered to be statistically significant in the entire study. All hypotheses were formulated using two-tailed alternatives against each null hypothesis. Data were analysed using R, version 4.2.2.[18]

Results

Population characteristics

We recruited 61 participants in our study. The median age of the participants was 63 (54–70) years. Forty-one participants (67%) were males, and 20 participants (33%) were females.

Comorbid status

Twenty-two participants (36%) had been diagnosed with diabetes mellitus in the past, and 44 participants (72%) had been diagnosed with AHA stage I or higher hypertension in the past.

Symptomatology and stroke characteristics

The median duration of presentation after symptoms started was 24 (6–24) hours. Forty-three patients (70%) were diagnosed with ischemic strokes, and eighteen patients (30%) were diagnosed with haemorrhagic strokes radiologically.

Stroke severity and prognosis

The median modified NIHSS score was 4 (2–8). The median modified Rankin scale was 3 (1–4).

Correlation between modified Rankin scale and modified NIHSS

The Spearman's rank correlation test was performed to assess the correlation between mRS and mNIHSS. The test was positive, statistically significant, and very large (rho = 0.866, 95% CI [0.751, 0.925], S = 5062.62, *P* = 2.2e-16) [Figure 1].

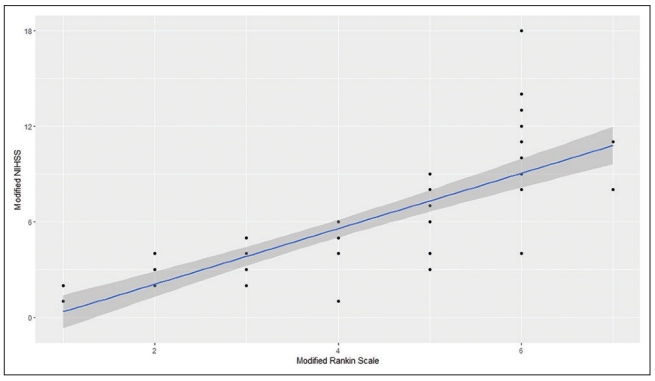

Figure 1: Scatterplot and a best-fit line with 95% shaded confidence bands for the modified Rankin scale and modified NIHSS

Ordinal regression to predict mRS with mNIHSS

An ordered logistic regression analysis was performed to assess the relationship between mRS and mNIHSS. On unadjusted analysis, for every one-point increase in the modified NIHSS, the odds of having higher mRS scores are 145% more (OR = 2.451, 95% CI [1.868, 3.397], *P* = 3.6e-09) [Figures 2 and 3].

After adjusting for age, sex, duration after symptom onset, presence of diabetes mellitus, presence of hypertension and ischemic/haemorrhagic stroke, for every one-point increase in the modified NIHSS, the odds of having higher mRS scores are 153% more (aOR = 2.534, 95% CI [1.904, 3.560], *P* = 4.8e-09).

Linear regression to predict factors affecting mNIHSS

Univariate and multiple linear regression analyses are performed to assess the effects of various explanatory variables on mNIHSS findings. Duration since symptom onset and the type of stroke (haemorrhagic/ischemic) were associated with mNIHSS scores [Table 1].

Ordinal regression to predict factors affecting mRS

Univariate- and multiple-ordered logistic regression analyses are performed to assess the effects of various explanatory variables on mRS findings. The type of stroke (haemorrhagic/ischemic) is associated with mRS scores [Table 2].

Discussion

This cross-sectional single-centre study aimed to investigate the relationship between stroke severity as measured by modified National Institutes of Health Stroke Scale (mNIHSS) and modified Rankin Scale (mRS) and factors affecting them. The study recruited 61 participants from a tertiary care hospital in western India. The results revealed that the majority of the participants were male, and most of them had a history of hypertension, followed by diabetes mellitus. The median duration of symptom onset was 24 hours. The majority of patients were diagnosed with ischemic stroke. The median modified NIHSS score was 4, and the median modified Rankin scale was 3. The

Spearman's rank correlation test revealed a strong positive correlation between mRS and mNIHSS. An ordered logistic regression analysis revealed that for every one-point increase in mNIHSS, the odds of having higher mRS scores increased by 145% (OR = 2.451, 95% CI [1.868, 3.397], *P* = 3.6e-09). After adjusting for various confounding factors, this relationship persisted (aOR = 2.534, 95% CI [1.904, 3.560], *P* = 4.8e-09). Linear regression analysis revealed that duration since symptom onset and the type of stroke (haemorrhagic/ischemic) were associated with mNIHSS scores, while the type of stroke was associated with mRS scores.

Our study's findings are consistent with previous studies that have investigated the relationship between mRS and mNIHSS in stroke patients.[14] These findings suggest that the mNIHSS score can be a reliable predictor of stroke outcomes and can help identify patients who are at risk of poor outcomes.

Our study's findings also support previous studies that have identified hypertension as a major risk factor for stroke.[19] These findings suggest that hypertension management should be a priority in stroke prevention and management.

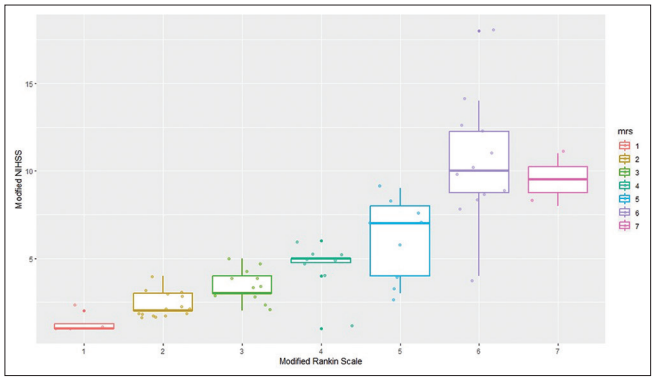

Figure 2: Boxplots with jittered raw data of the modified NIHSS for each level of the modified Rankin scale

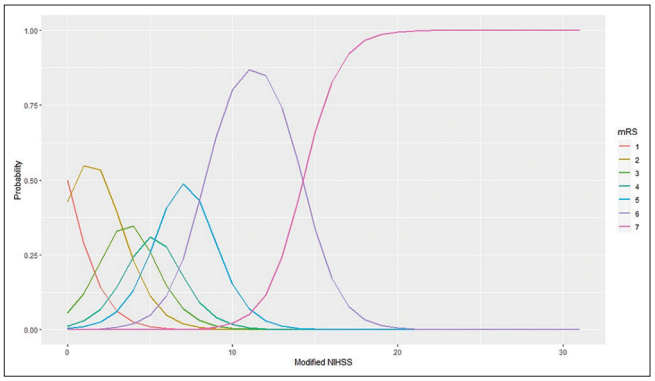

Figure 3: Probability distributions of the modified NIHSS for each level of the modified Rankin scale

Table 1: Linear regression analysis to predict mNIHSS with explanatory variables

Characteristic		mNIHSS (unadjusted)			mNIHSS (adjusted)		
	n	Beta	95% CI1	*P*	Beta	95% CI1	*P*
Age (years)	61	0·00	-0·06 to 0·07	0·89	-0·04	-0·10 to 0·03	0·28
Sex	61						
Female		—	—		—	—	
Male		-0·65	-2·7 to 1·4	0·52	-1·3	-3·1 to 0·50	0·15
Duration since onset (hours)	61	0·05	0·01 to 0·08	0·012	0·03	0·00 to 0·07	0·047
Diabetes mellitus	61	-1·3	-3·3 to 0·63	0·18	-0·72	-2·5 to 1·0	0·41
Hypertension	61	1·1	-0·98 to 3·2	0·29	0·75	-1·3 to 2·8	0·46
Type of stroke	61						
Haemorrhagic		—	—		—	—	
Ischemic		-3·7	-5·6 to -1·9	0·0002	-3·7	-5·7 to -1·8	0·0004

1 CI=Confidence Interval

Table 2: Ordered proportional odds logistic regression analysis to predict mRS with explanatory variables

Characteristic		mRS (unadjusted)			mRS (adjusted)		
	n	OR1	95% CI1	*P*	OR1	95% CI1	*P*
Age (years)	61	0·99	0·96 to 1·02	0.66	0·97	0·94 to 1·01	0.12
Sex	61						
Female		—	—		—	—	
Male		0·88	0·33 to 2·31	0.80	0·61	0·22 to 1·66	0.32
Duration since onset (hours)	61	1·01	0·99 to 1·03	0.26	1·00	0·99 to 1·02	0.68
Diabetes mellitus	61	0·57	0·22 to 1·45	0.24	0·64	0·23 to 1·73	0.37
Hypertension	61	1·69	0·63 to 4·64	0.30	1·94	0·63 to 5·98	0.25
Type of stroke	61						
Haemorrhagic		—	—		—	—	
Ischemic		0·25	0·09 to 0·68	0.0071	0·22	0·07 to 0·65	0.0070

1 OR=Odds ratio, CI=Confidence interval

Our study's findings also suggest that the type of stroke (haemorrhagic/ischemic) has a significant impact on stroke severity and prognosis. Several previous studies have investigated the differences in stroke severity and outcomes between haemorrhagic and ischemic strokes. A study by Salvadori *et al.* found that haemorrhagic stroke patients had worse outcomes than ischemic stroke patients, as measured by mRS scores.[20] Similarly, a study by Andersen *et al.* found that haemorrhagic stroke patients had higher mortality rates than ischemic stroke patients.[21] These findings highlight the importance of accurate and timely diagnosis of stroke type to facilitate appropriate management and improve outcomes.

The findings of our study are particularly pertinent for primary care physicians, who play a crucial role in both the early detection of stroke and the long-term management of stroke survivors. Given the strong correlation between mNIHSS scores and functional outcomes, as indicated by the mRS, primary care providers can utilize these tools to more effectively triage stroke patients, even in time-constrained environments. This can lead to prompter referrals to specialized care and a more tailored approach to early interventions. Furthermore, the identification of hypertension as a significant predictor of stroke severity underscores the importance of proactive management of hypertension in primary care settings. Routine screening and aggressive management of hypertension could be a key strategy in stroke prevention. Additionally, the distinction between the impacts of haemorrhagic and ischemic strokes on patient outcomes serves as a reminder of the necessity for primary care physicians to be adept in differentiating stroke types and understanding their respective management protocols. This knowledge is essential not only for immediate care but also for guiding patients through their recovery journey, addressing complications, and implementing secondary prevention strategies. Thus, our study's insights contribute to a more nuanced understanding of stroke management in primary care, emphasizing the need for comprehensive training and updated knowledge in this area to improve patient outcomes.

Despite its strengths, our study has several limitations. First, it was a cross-sectional study, which limits the ability to establish causal relationships between variables. Second, the sample size was relatively small, which may limit the generalizability of the findings. Third, we only assessed a limited number of variables, and other factors that may impact stroke severity and outcomes, such as smoking status, alcohol consumption, etc.

In conclusion, our study shows that the initial stroke severity as measured by the mNIHSS strongly correlates with the overall functional outcomes at 8th day of hospitalization or upon discharge as measured by the mRS. Thus, mNIHSS can be reliably used to predict the functional outcomes for patients with stroke in time constrained settings. We also found the presence of hypertension in patients to be a strong predictor of initial stroke severity. The type of stroke also influences the overall functional outcomes with haemorrhagic stroke having a worse prognosis than ischemic stroke.

Abbreviations

mNIHSS = Modified National Institute of Health Stroke Scale, mRS = Modified Rankin Scale.

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Conflicts of interest

There are no conflicts of interest.

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