Reliability of the Acutely Estimated Premorbid Modified Rankin Scale for Stroke Treatment Decision Making

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Background: Premorbid functional status is an important factor in acute stroke treatment decision making. Determining the modified Rankin Score (mRS) accurately may be difficult due to deficits from stroke and lack of collateral information in the acute setting. Data on the reliability of the premorbid mRS in "real-world" practice outside of clinical trial or registry settings are limited. *Methods:* A retrospective study at a high volume academic primary stroke center. For patients with acute ischemic stroke treated with alteplase between July 2012 and July 2016, hospital electronic records were reviewed for detailed inpatient occupational therapist (OT) assessment of premorbid functional status to determine mRS (OT-mRS). This was compared with premorbid mRS determined at acute emergency department assessment (Acute-mRS). Kappa statistic and Lin's concordance correlation coefficient was used to calculate agreement between Acute-mRS and OT-mRS. *Results:* Among stroke patients treated with alteplase over the 4 years period, OT-mRS was available for 312 patients (79.0%), the mean age was 75.5 years (male 51.9%). 82.4%, 11.9%, and 5.8% of patients had Acute-mRS of 0-1, 2, and ≥3; while 84.9%, 8.0%, and 6.7% had OT-mRS of 0-1, 2, and ≥3, respectively. The agreement between Acute-mRS and OT-mRS was 83.3%, with $\kappa = .64$ and correlation coefficient r = .87 (95% CI .841-.896, $P < .05$). *Conclusions:* There was at least moderate agreement between Acute-mRS prior to thrombolysis and OT-mRS obtained by detailed assessment later. The number of patients with premorbid disability was small and may have positively influenced the agreement between the 2 scores.

Key Words: Premorbid function—modified Rankin Score—reliability—acute ischemic stroke—thrombolysis

Introduction

Many patients with acute ischemic stroke (AIS) already have premorbid disability and comorbidity,and are often excluded in acute stroke thrombolysis studies due to conventional dichotomous analysis of outcome assessments.[1,2] Thrombolytic treatment should be considered in AIS patients with mild to moderate pre-existing disability as about one fourth-one third of thrombolysed patients returned to their premorbid functional levels at 90 days.[1,3]

Modified Rankin Score (mRS) was not initially designed for assessment of premorbid function yet it has been adopted as a premorbid disability assessment tool both in research and in routine clinical practice.[4] The mRS is indispensable in acute stroke treatment decision making. Compared to those without premorbid disability, patients with premorbid disability (mRS >1) are older, have more vascular risk factors, tend to present with more severe stroke, and are more likely to die.[3,5] Although premorbid disability is not a contraindication for thrombolysis, the

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proportion of intravenous alteplase treated patients with at least slight pre-existing disability (mRS >1) has not significantly increased over time (6%-8%).[3,6,7]

Moderate validity of mRS was reported by Quinn et al using data from a large UK clinical registry.[8] They also found that age at time of stroke, premorbid residence, premorbid care, and Charlson comorbidity index were all associated with premorbid mRS.[8] Moderate interobserver reliability (k = .58 (95% CI, .46-.70)) for premorbid mRS was reported by Fearon et al, who also reported moderate correlations between premorbid mRS and premorbid comorbidity and frailty.[9] Therefore, it is reasonable to use premorbid mRS to describe premorbid function.

In the hyper-acute setting, the reliability and validity of mRS in the rapid assessment of premorbid function are not known. Determining the premorbid mRS accurately and quickly may be difficult for many reasons, including deficits from acute stroke and lack of collateral information.

We hypothesed that premorbid mRS documented in the acute setting is reliable compared to mRS calculated using detailed functional information from occupational therapist (OT) assessment conducted in the postacute inpatient setting.

Methods

This was a retrospective study at a high volume academic primary stroke center. The departmental stroke database was interrogated for patients with AIS treated with alteplase between July 2012 and July 2016.

All treated patients underwent 24 hour post-treatment brain CT. Age, sex, vascular risk factors, premorbid residence, premorbid functional status (assessed using mRS), initial National Institutes of Health Stroke Scale (NIHSS) score, onset and door to needle times, length of stay, symptomatic intracranial haemorrhage (sICH) and asymptomatic ICH, discharge destinations, death, and 3-month mRS were collected. Premorbid mRS determined in the acute emergency department (ED) setting (Acute-mRS) was performed by certified mRS assessors including stroke nurses, stroke registrars, and neurologists, for all treated patients as routine practice.

A detailed inpatient OT qualitative assessment of premorbid functional status by qualified OT were performed for all stroke patients, unless deemed not indicated/appropriate by the medical team based on patient's clinical status. The domains of OT assessment include mobility, self-care tasks (showering, dressing, toileting, eating, and medication management), household tasks (cooking, cleaning, laundry, gardening, letterbox, and rubbish), community tasks (driving/transport, shopping/banking, interest/work), cognition, mental state, and upper limb function. The detailed OT assessments documented in the hospital medical record were reviewed by one of the authors (W.Z.) and then used to determine mRS (OT-mRS). Characteristics and risk factors were compared between AIS patients with and without OT assessment. OT-mRS and Acute-mRS were compared to determine agreement between them.

Patients with premorbid Acute-mRS 0-1 were considered as premorbid independent, while patients with Acute-mRS ≥2 as premorbid disabled. To assess the validity of the Acute-mRS compared to OT-mRS, we explored the associations between these variables and discharge destinations and mortality/functional outcomes. The study was approved by the Institutional Ethics Board.

Statistical Analysis

The frequency distributions of categorized variables were compared by using Fisher exact test, and student's t test as appropriate. The significance level was set at $P < .05$. The Acute-mRS and OT-mRS were compared using the kappa statistic and Lin's concordance correlation coefficient.

Reliability refers to the extent to which a scale consistently and reproducibly measures the attributes it was intended to measure. The κ statistic indicates the extent of agreement among different sets of results not occurring by chance. Strength of agreement for the κ statistic has been categorized as follows: <0 = poor; 0-.20 = slight; .21-.40 = fair; .41-.60 = moderate; .61-.80 = substantial; .81-1.00 = almost perfect.[10] Lin's concordance correlation coefficient can also be used to assess agreement between different measurements: 0 is no correlation, near ±1 is perfect concordance (or perfect discordance).[11] Analysis was performed using Stata 14 (StataCorp LP, College Station, TX).

Results

Patient Characteristics

There were 967 patients admitted to our center with AIS within the thrombolysis window (4.5 hours) from July 2012 to July 2016, and 395 (40.8%) patients were treated with intravenous alteplase. Among alteplase treated patients, 312 patients (79.0%) with detailed inpatient OT assessment were included in the analysis. There were no patients with premorbid mRS 5 treated with thrombolysis during the study period. Mean age was 75.5 years (±12.9), 51.9% were male.

When comparing tissue plasminogen activator (tPA) treated AIS patients with and without (83 patients) detailed OT assessment in hospital, no significant differences in characteristics were found (Table 1). However, patients who did not receive inpatient OT assessment were found to have more severe stroke at presentation than patients with OT assessment (NIHSS median score 10.5 versus 8, $P < .04$).

Comparing premorbid independent (mRS 0-1) and premorbid disabled patients with univariable analysis, premorbid disabled patients were significantly older, more likely to be female, and more likely to have atrial fibrillation, ischemic heart disease, congestive cardiac failure, and previous stroke ($P < .05$) (Table 2).

Table 1. *Comparing characteristics of tPA treated AIS patients with and without detailed OT assessment*

	Patients with OT N = 312	Patients without OT N = 83	*P* values
Age (mean ± SD, y)	75.5 ± 12.9	76.7 ± 11.1	.4
Male, n (%)	161 (51.6)	42 (50.6)	.9
Premorbid Acute-mRS (median)	0	0	1.0
Comorbidities, n (%)			
Atrial fibrillation	109 (34.9)	33 (39.8)	.4
Hypertension	215 (68.9)	57 (68.7)	1.0
Hypercholesterolemia	112 (35.9)	34 (41.0)	.4
Diabetes	46 (14.7)	17 (20.5)	.2
Stroke	76 (24.4)	17 (20.5)	.6
IHD/CCF	89 (28.5)	23 (27.7)	1.0
Smoker	34 (10.9)	7 (8.4)	.7
Ex-smoker	34 (10.9)	10 (12.1)	.8

AIS, acute ischaemic stroke; IHD/CCF, ischaemic heart disease/ congestive cardiac failure; mRS, modified Rankin Scale; N, total number; n, a sample of the total number; OT, occupational therapist; SD, standard deviation.

In clinical settings, patients with mRS 0-2 are generally considered as "good functioning". When comparing with patients with premorbid mRS ≥3, patients with mRS 0-2 in our cohort were significantly younger, more likely to be male, and less likely to have previous stroke ($P < .05$) (Supplementary Table 1).

Agreement Between Acute-mRS and OT-mRS

With regards to premorbid mRS assessment in the acute setting (Acute-mRS), 257 (82.4%), 37 (11.9%), and 18 (5.8%) of the 312 patients had score of 0-1, 2, and ≥3; while 265 (84.9%), 25 (8.0%), and 22 (6.7%) of patients had OT-mRS of 0-1, 2, and ≥3, respectively.

When assessed using the kappa statistic, the agreement between Acute-mRS and OT-mRS assessments was 83.3% (κ = .64, weighted κ = .77). The agreements between individual Acute-mRS and OT-mRS scores were 89.4% (κ = .75 for mRS 0), 88.1% (κ = .48 for mRS 1), 93.0% (κ = .61 for mRS 2), 96.8% (κ = .69 for mRS 3), and 99.4% (κ = .66 for mRS 4) (Table 3). Lin's concordance correlation coefficient assessment produced r = .87 (95% CI .841-.896, $P < .05$).

Table 2. *Characteristics comparing patients with premorbid Acute-mRS 0-1 and Acute-mRS ≥2*

	Premorbid mRS 0-1 N = 257	Premorbid mRS ≥ 2 N = 55
Age*, median (SD)	76.0 (13.1)	86.0 (7.5)
Male*, n (%)	146 (56.8)	16 (29.1)
Comorbidities, n (%)		
AF*	81 (31.5)	27 (49.1)
Hypertension*	173 (67.3)	42 (76.4)
Diabetes	33 (12.9)	12 (21.8)
Cardiac disease (IHD/CCF)*	67 (26.1)	22 (40.0)
Stroke*	55 (21.0)	20 (36.4)
Ex-smoker	28 (10.9)	6 (10.9)
Current smoker*	33 (12.8)	1 (1.8)
Hypercholesterolemia	95 (37.0)	18 (32.7)
Door-to-needle time−−min (median, SD)	57 (66.7)	58 (81.7)
Onset-to-needle time−−min (median, SD)	140 (56.3)	146 (57.2)
Length of stay-days (median, SD)	6 (7.7)	7 (6.4)
aICH, n (%)	20 (7.8)	6 (10.9)
sICH, n (%)	3 (1.2)	3 (5.5)
Discharged home at 3 months*, n (%)	214 (83.3)	20 (36.4)
Discharged to NH*, n (%)	20 (7.8)	17 (30.9)
Died within 3 months*, n (%)	19 (7.4)	17 (30.9)

aICH, asymptomatic ICH; AF, atrial fibrillation; IHD/CCF, ischaemic heart disease/ congestive cardiac failure; ICH, intracranial haemorrhage; NH, nursing home; mRS, modified Rankin Scale; N, total number; n, a sample of the total number; SD, standard deviation; sICH, symptomatic intracranial haemorrhage.

*means $P < .05$.

Table 3. *Agreement between Acute-mRS and OT-mRS*

	Acute-mRS						
OT-mRS	0	1	2	3	4	5	Total
0	204	13	4	0	0	0	221
1	14	22	8	0	0	0	44
2	2	1	20	2	0	0	25
3	0	1	5	12	1	0	19
4	0	0	0	1	2	0	3
5	0	0	0	0	0	0	0
total	220	37	37	15	3	0	312
Agreement	89.4%	88.1%	93.0%	96.8%	99.4%		

mRS, modified Rankin Scale; OT, occupational therapist.

Discharge Destinations

Prior to stroke, 294 (94.2%) of patients lived in their private residence, 15 (4.8%) lived in a nursing home, and 3 (1%) were inpatients when AIS occurred. Three months after alteplase treatment, 36 (11.5%) of the patients died, 5 (1.6%) remained in a rehabilitation ward, and 234 (75%) of patients returned home, while 37 (11.9%) were discharged to a nursing home.

When comparing patients with Acute-mRS 0-1, patients with Acute-mRS ≥2 were significantly less likely to be discharged home at 3 months (36.4% versus 83.3%, $P < .05$) (Table 2). Similar results were found when OT-mRS was used for assessment of premorbid function (29.8% versus 83.0%, $P < .05$).

Variables Associated with Mortality and Poor Functional Outcome

Patients with Acute−mRS ≥2 were more likely to die than those with Acute-mRS 0-1 (30.9% versus 7.4%, $P < .05$) (Table 2). Similar death rates were found when OT-mRS was used (36.2% versus 7.2%, $P < .05$).

When comparing patients with Acute-mRS 0-2 ("good functioning"), patients with Acute-mRS ≥3 had higher sICH rate (11.1% versus 1.4%, $P = .04$), and higher death rate (38.9% versus 9.9%, $P = .002$) (Supplementary Table 1). Further, at 3 months, 65.7% of these patients returned to their premorbid functioning of mRS 0-2; while only 44.5% of patients with premorbid Acute-mRS 3-4 returned to similar functional level (Supplementary Table 2).

Age, premorbid mRS (Acute-mRS), NIHSS at presentation as indication of stroke severity, some cerebrovascular risk factors (atrial fibrillation, diabetes mellitus, and ischemic heart disease/ congestive cardiac failure), and sICH post-thrombolysis were shown to be associated with worse functional outcome at 3 months assessed by mRS ($P < .05$). With the exception of diabetes mellitus, the same variables were also shown to be associated with increased mortality ($P < .05$).

Discussion

Accurate assessment of premorbid functional status in the acute setting is important for determining suitability and prognosis for thrombolysis treatment. To our knowledge, the reliability of premorbid functional assessment using the mRS in the acute ED setting has not previously been reported. In our cohort, premorbid mRS assessment in the acute setting with often limited information was concordant with premorbid mRS derived from nonemergent, detailed OT assessment, with κ ranging from .48 to .75 for individual mRS categories, which indicates moderate to substantial reliability of Acute-mRS. This was again shown using a different analysis method of correlation coefficient.

Quinn et al have previously demonstrated that premorbid mRS is a robust predictor of prognosis with evidence that every point increase of premorbid mRS is associated with poorer outcomes (early and late mortality, length of stay, institutionalization, and incident complications).[8] In our cohort, Acute-mRS was shown to be associated with discharge destinations, 3-month poststroke functional status (assessed using poststroke mRS), and mortality.

Limitations

The usual limitations associated with a retrospective, single center observational study apply to this study. The number of patients with premorbid disability (Acute-mRS ≥2) was small and may have positively influenced the agreement between the 2 scores. Interobserver variability is one recognised weakness of mRS, varying from "near perfect" agreement (weighted κ = .95) to "poor" agreement (κ = .25), although overall reliability is moderate (κ = .46) and improves to κ = .87 with structured interview.[12] The Acute-mRS was assessed by different members of the stroke team and not a single assessor, this reflects real world practice. The poststroke mRS was conducted by one of the authors (W.Z.) based on information documented by an OT, not conducted by direct face-to-face interview as best validated method. We therefore cannot exclude measurement bias in both acute and poststroke mRS.

Conclusion

Premorbid mRS assessment performed in the ED by the acute stroke team is reliable and can be used to guide acute treatment decision making.

Supplementary materials

Supplementary data to this article can be found online at doi:10.1016/j.jstrokecerebrovasdis.2018.12.026.

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