A simple risk score for early ischemic stroke mortality derived from National Institutes of Health Stroke Scale: A discriminant analysis

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ABSTRACT

Objectives: The aim of the current study was to design a new simpler form of National Institutes of Health Stroke Scale (NIHSS) for use in emergency settings, and compare its predictive ability with original NIHSS score for mortality.

Methods: A total of 152 consecutive patients with first ever ischemic stroke admitted to a university affiliated hospital were recruited. NIHSS score on admission was estimated and the predictive ability of NIHSS items for mortality at 28 days was evaluated by logistic regression. Stepwise discriminant analysis was performed on NIHSS items to obtain a discriminant function with the best discriminative ability for mortality. Further, receiver operating characteristics (ROC) curves were depicted to compare the new determined discriminant function with the original NIHSS score.

Results: Cumulative rate of mortality was 11.8% for 28-day follow-up period. Among NIHSS items, scores of visual field, limb ataxia and extinction neglect were not associated with mortality (P > 0.05). On the contrary, level of consciousness–commands, language and gaze were determined as independent indicators of mortality (P < 0.05), and their coefficients on discriminant function were equal to 0.65, 0.44 and 0.30, respectively. In addition, area under the ROC curve of the calculated discriminant function was not statistically different from NIHSS score (P > 0.05).

Conclusions: The suggested discriminant function, comprising NIHSS items of level of consciousness–commands, language and gaze, can predict 28-day mortality after ischemic stroke in a similar way to the original NIHSS score and can provide a baseline for stroke severity in emergency settings.

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1. Introduction

Stroke as a major global health problem, is the second most common cause of death in Eastern-Mediterranean countries [1]. Stroke is also the leading cause of adult long-term disability and represents an enormous burden on society, which is likely to increase in future decades as a result of demographic transitions in populations [2,3]. Stroke incidence and mortality rate have changed substantially over time. Mortality rate has declined in many countries, which may be at least in part due to improved health care services [4–8]. Likewise, many population studies show decrease in stroke incidence, but not always in concordance with mortality [5,9,10]. On the contrary, stroke incidence reflected by hospital admission rate has been reported to be rising in an urban area of Iran during a four-year period [11]. Another population study in Iran, after adjusting for age has found higher incidence of stroke compared to most western countries [12]. In addition, because of rapid aging of Iranian population, further rising in stroke incidence is not implausible [13]. These facts would make stroke as serious national health care problem.

The National Institutes of Health Stroke Scale (NIHSS) is the most frequently used scale for evaluating stroke patients [14–16]. It assesses consciousness, eye movement, visual field, sensory and motor impairment, ataxia, speech and inattention [16]. The NIHSS's reliability as well as its ability to predict patients' outcomes, has helped to promote its use in different clinical settings [16–19]. Along with other clinical examinations, NIHSS has been used to determine which stroke patients benefit the most from therapeutic options such as thrombolysis. Review of previous studies shows that patients with NIHSS values lower than 4 may not be considered as a candidate for reperfusion therapy [20,21]. Further, recovery
of patients’ symptoms after thrombolysis is related to the level of NIHSS on admission [22,23].

Prognostic models designed for evaluating the outcome of stroke can be utilized in decision-making (e.g. choosing the appropriate therapeutic option) and can also help clinicians to stratify mortality risk in emergency centers. Therefore, recognition of determinants of stroke outcome is of paramount importance and is the topic of some prior studies. For instance, Arboix et al. revealed that level of consciousness, vomiting, cranial nerve palsy and seizure are independently associated with in-hospital mortality in stroke patients [24]. The aim of the current study was to develop a simple score derived from NIHSS items which contributes the most to early mortality after stroke. Further, the diagnostic accuracy of the designed score was compared with the original NIHSS scale.

2. Methods

A series 230 consecutive patients with stroke who presented within 24 h after symptoms onset to our main University affiliated hospital-based stroke center from February 2009 to March 2010 were enrolled. Computed tomography (CT) and Magnetic resonance imaging (MRI) were performed on all patients. After excluding subjects with previous history of stroke events (n = 47) and those with hemorrhagic attacks (n = 31), analyses were performed on the remaining 152 first ever ischemic patients. All patients were followed up for at least 28 days.

Neurological and physical examinations as well as 12-lead electrocardiography and echocardiography were performed on all participants. Stroke severity on admission was assessed using NIHSS. CT scans and/or MRI sequences were conducted to diagnose size, location and type of stroke (ischemic versus hemorrhagic). Information on the etiology of ischemic strokes was collected according to the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria [25].

Analyses of data were conducted using SPSS software (version 16.0; SPSS Inc., Chicago, USA) and P value <0.05 was considered statistically significant. Cumulative mortality rate at the 28-day follow-up period was calculated for all hospitalized patients. Differences in baseline variables between survivors and non-survivors were assessed with the χ² test for proportions and the Student’s t-test for continuous variables. Items of NIHSS were included in univariate and multivariate analyses to define independent predictors of mortality. The next step involved performing stepwise discriminant analysis on items of NIHSS. The aim of the discriminant analysis is to weight and combine variable scores to a single new composite measure, discriminant function, which has the best predictive ability for the dependent variable. Finally, receiving-operating characteristic (ROC) curve analyses and the respective area under the ROC curves (AUC) were used to compare the predictive power of the newly determined discriminant function with NIHSS score. AUCs were compared by STATA software (ver 9.0, 2005).

3. Results

Cumulative rate of mortality was 11.8% for 28-day follow-up period. The mean age ± standard deviation (SD) of survivors and non-survivors were equal to 61.3 ± 14.9 and 64.2 ± 22.8 years, respectively (P = 0.05). Further, 57.5% and 50.0% of survivors and non-survivors were men, respectively (P = 0.05). According to the TOAST criteria, 19.7%, 27.0%, 16.4%, 3.3%, and 33.5% of patients were diagnosed with large-artery atherosclerosis, cardioembolism, small-artery occlusion, stroke of other determined etiology, and undetermined etiology, respectively. The highest mortality rates were observed for cardioembolism and large-artery atherosclerosis (19.5% and 16.7%, respectively for cardioembolism and large-artery atherosclerosis). Regarding NIHSS items, the most frequent abnormality was related to the motor items (46.8–63.2% for impairment of different limbs) and facial palsy (57.9%).

Univariate analyses revealed that among NIHSS items, scores of visual field, limb ataxia and extinction neglect were not associated with mortality (Table 1). After performing multiple stepwise logistic regression analysis on the items of NIHSS, level of consciousness (LOC)-commands, gaze and language were diagnosed as independent determinants of mortality (Table 2). Using discriminant analysis, LOC-commands had the highest predictive ability for mortality followed by language and gaze. The coefficients of LOC-commands, language and gaze on discriminant function were 0.85, 0.44 and 0.30, respectively.

The survival status of the 92.3% of the subjects was correctly classified by the calculated discriminant function. Furthermore, ROC analysis revealed that the AUC of the discriminant score for mortality was not significantly different from NIHSS score (0.90 vs. 0.91 for discriminant score and NIHSS, respectively, P > 0.05).

4. Discussion

The case fatality rate at 28 days was 11.8%. The current study shows that scores of visual field, limb ataxia and extinction neglect are not significantly associated with mortality. On the contrary, LOC-commands had the highest contribution to the mortality, followed by language and gaze. The analyses revealed that much of the predictive performance of the NIHSS criteria can be retained with our suggested score.

We estimated 28-day mortality rate at 11.8%, which is similar to the values reported by two previous studies in Iran (i.e. 15.3% and 19.2%) [26,27]. However, in another study on Iranians, fatality rate was reported at 25.8% for ischemic strokes [11]. One possible reason for better outcomes of stroke in the current study is

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<th>Table 1</th>
<th>Univariate analysis of NIHSS items for 28-day mortality.</th>
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<td>Dysarthria</td>
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<td>Extinction neglect</td>
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* P < 0.05.
** P < 0.01.
*** P < 0.001.

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<th>Table 2</th>
<th>Multivariate analysis of NIHSS items for 28-day mortality.</th>
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* P < 0.05.
** P < 0.01.
that we used data from a highly university-affiliated hospital based stroke center. Further, the enrolled subjects were younger than that of aforementioned study (P<0.05, conducted by STATA software, ver 9.0, 2005). Our findings are also comparable to the figures in Japan (14.2% for men and 19.1% for women), France (12.5%), Ukraine (15.4% for hospitalized patients), and the Caribbean and Latin American countries (19.3–26.2%) [5,28–30].

NIHSS has high inter-rater reliability when performed by different health care professionals [15]. Further, NIHSS has been shown to be valid and to have high predictive ability of discharge and stroke outcomes at different intervals following the onset of symptoms [31–33]. By contrast, NIHSS is also reported to have some redundant items with poor reliability. For instance, facial palsy, limb ataxia, dysarthria and extinction neglect have low reliability indices [14,34,35]. In this respect, we found that limb ataxia and extinction neglect are not associated with 28-day mortality and facial palsy is merely weakly related to mortality. On the contrary, in the current study LOC commands, gaze and language were diagnosed as independent determinants of mortality and contributed to development of a new discriminant score. Review of previous studies shows that these three items generally have high reliability [14,35,36].

Lyden et al. introduced a modified NIHSS by removing poorly reproducible items (i.e. LOC, facial palsy, ataxia and dysarthria) and showed that the yielded scale is clinimetrically identical to the original NIHSS [37]. Subsequently, another study revealed that although the validity of this modified version of NIHSS is close to the original one, its reliability is higher [38]. Tirschwell et al. developed a shortened version of NIHSS which had similar predictive ability to the original one [39]. The current study suggests a discriminant score, comprising three items, with comparable diagnostic accuracy to the original NIHSS. Because of its simplicity it can be readily used in emergency prehospital conditions to assess the stroke outcome.

In the field of triage, prehospital stroke scales can be helpful in the estimation of stroke severity and can develop a basis for triage decisions. In this respect, the Los Angeles and Cincinnati Prehospital stroke scales have been originally designed to diagnose stroke patients in prehospital settings [40,41]. It has been shown that Cincinnati scale has high ability in identifying stroke patients who are candidates for thrombolytic therapy [41]. In contrast, our suggested score is designed for prediction of early mortality after ischemic stroke. Thus, further studies are needed to determine whether this newly designed score can be also used for diagnosis of reperfusion therapy candidates.

Besides NIHSS items, some other factors may also contribute to stroke mortality. For instance, cardiovascular risk profile of patients is related to stroke outcome [42]. Further, age not only influences the outcome of stroke events, it may also affect the frequency and distribution of cardiovascular risk factors [43,44]. In this respect, congestive heart failure, atrial fibrillation and chronic renal disease occur more frequently in subjects older than 85 years of age and are considered as modifiable risk factors to prevent ischemic stroke in this age group [45].

This study also has some strengths and limitations. Since all subjects were admitted to a single university affiliated stroke center, the factors related to the hospital setting were similar. Further, although it has been shown that there is good concordance between NIHSS scores generated by different health care professionals, in our study NIHSS was examined by neurologists [19,46]. The potential limitation is that we used a hospital-based study population, which may confine our ability to extend our findings.

In conclusion, we found that NIHSS assessments performed on patients’ arrival can be used to predict mortality at 28 days. Among NIHSS items, LOC commands, language and gaze have the highest contribution to 28-day mortality. The score derived from these three items has similar predictive ability to the original NIHSS. Our study provides useful information regarding early risk stratification for stroke patients and is valuable for patients’ management in the field. However, further prospective studies may be needed in the prehospital settings to determine whether our suggested score offers an improvement by simplifying NIHSS criteria. Finally, considering the effectiveness of reperfusion therapy only in the few hours after symptom onset, it could also be of interest to identify how this score can help clinicians to choose the appropriate patients for reperfusion therapy.

Conflict of interest
The authors declare no conflicts of interest.

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