Novel Algorithm to Help Identify Stroke Mimics

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Background: Stroke is a major cause of disability in the United States. A portion of patients presenting with stroke-like symptoms in the emergency room who receive tissue plasminogen activator (tPA) do not end up having a true stroke, leading to unnecessary health-care costs. The aim of our study is to identify those patients who have a high likelihood of experiencing a stroke mimic using a novel stroke mimic score and to identify a cutoff point with a high specificity of ruling in stroke mimics. *Methods:* We reviewed literature on stroke mimics and the various associated risk factors. We devised a 9-point scoring system and applied it retrospectively to patients who received tPA from 2010 to 2014 to calculate a score for each patient. *Results:* The final sample size was 105 patients, out of which 25% turned out to be patients with stroke mimics. Patients with stroke mimic were significantly younger and more likely to have history of seizure, migraine, or prior psychiatric illness. History of atrial fibrillation had the highest correlation with true stroke. We found approximately 100% specificity in ruling in a stroke mimic if a patient scored more than 5 points. *Conclusions:* Our stroke mimic scoring system along with a basic neurologic examination could be a useful tool in the identification of stroke mimics with a high specificity in the emergency room setting. These patients may require further studies such as rapid magnetic resonance imaging, which would decrease unnecessary tPA administration and hospital admissions. **Key Words:** Stroke—mimic—rapid sequence MRI—tissue plasminogen activator—algorithm.

Background and Purpose

Stroke is the fifth leading cause of death in the United States. About 800,000 people have stroke every year, and the annual cost is around $33 billion, including the cost of health-care services, medication, and lost productivity.[1] However, a significant number of patients with stroke-like symptoms do not have a stroke. These stroke mimics (SM) comprise approximately 9%-30% of suspected strokes. Causes of SM include intracranial tumors, vertigo, migraines, hypoglycemia, Todd paresis, sepsis, delirium, and functional disorders.[2-6] Because of time sensitivity involved in decision-making regarding tissue plasminogen activator (tPA) administration and established safety of intravenous tPA,[7] a significant number of SM end up receiving tPA, resulting in unwarranted hospital stays, unnecessary diagnostic tests, and invasive procedures.

Numerous articles have been published to identify the predictors of SM.[3,5,8] Hemmen et al reported that out of 411 patients presented to the emergency department as Code Stroke, 104 (25.3%) were discharged without a diagnosis of stroke or transient ischemic attack.[2] Patients with SM are younger patients (<50 years) with minimal risk factors.[3,6,8] Several variables have been identified to differentiate SMs from stroke victims, including absence of atherosclerosis on computed tomographic angiography; absence of risk factors including atrial fibrillation, hypertension, and diabetes mellitus; no focal weakness on examination; and history of migraine, epilepsy, and paresthesias.[3,6,8] Among these, the strongest predictors of SMs based on strength of association are age less than

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Table 1. *Stroke mimic scoring system*

Predictors of acute stroke mimics		
Age	<50 y	2 points
	50-70 y	1 point
	>70 y	0 points
Stroke risk factors: hypertension, hyperlipidemia, diabetes mellitus, atrial fibrillation (AF)		
If no risk factors		3 points
If risk factors = 1 without AF		2 points
If risk factors ≥ 2 without AF		1 point
Presence of AF		0 points
Other factors		
History of migraine		2 points
History of epilepsy		1 point
History of psychiatric illness		1 point

50 years, no history of atrial fibrillation, no focal neurologic weakness, and history of migraine headaches. Despite these known factors, there is no good clinically validated scale that could help a physician especially a non-neurologist to safely identify these patients and do further investigations such as rapid magnetic resonance imaging (MRI) before giving tPA.

In this study, we aim to identify patients who have a very high likelihood of experiencing a SM using a novel SM scale derived from the risk factors identified in the literature and listed in Table 1. We applied this scale to the retrospectively collected data to identify a cutoff point with a high specificity for "ruling in" SM, and propose an SM algorithm to help identify and selectively triage these patients in the acute setting.

Materials and Methods

Development of Stroke Mimic Scale

We performed a review of previously published articles ranging from 1995 to 2016 on acute SM and identified several factors that are positively or negatively associated with these patients.[3,5,8] The strength of association was measured using previously given odds ratios and *P* values. We identified risk factors that are easy to acquire in an emergency setting and formulated a 9-point scoring system (Table 1). Because absence of focal weakness may present in patients with a conversion disorder but not deemed a true weakness when presented, it was not included in the score. Also, the proposed algorithm is specifically developed as a supporting tool for those patients who are already considered at high risk of experiencing SM (which would include patients who have vague neurologic symptoms or functional weakness).

Data Source

Memorial Medical Center is an accredited tertiary care hospital and comprehensive stroke center located in Springfield, Illinois, that has a population of over 100,000. The hospital also serves a tertiary care center for several small hospitals in Central and Southern Illinois. An institutional review board approval was taken to collect the data on patients who received tPA between January 2010 and December 2014.

Study Population

All patients between the age of 18 and 90 years and received tPA between January 2010 and December 2014 were identified using the The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code of 99.10 (patients receiving tPA for acute stroke and pulmonary embolism). Also, patients transferred from the outlying hospital after tPA infusion were identified using the diagnosis code 45.88 and ICD-9-CM code 99.10. We obtained data relating to patient demographics, clinical presentation, risk factors, imaging features, and treatment information of all patients who received tPA for acute stroke presentation.

Statistical Analysis

The SM scoring system was applied to patient data to calculate a score for each patient (Table 1). The score ranged from 0 to 9. Comparison of baseline characteristics between SM and actual strokes were done using a chi-square test of independence for categorical variables. A logistic regression was performed to determine if the total score predicted SM. Sensitivity and specificity were calculated for total score, and a receiver operating characteristic curve (Fig 1) was generated to determine the cutoff value for the algorithm. Significance was determined at the .05 level.

Result

Characteristics of the Study Population

We identified a total of 501 patients using the abovementioned ICD-9-CM code. Because the list also included patients receiving tPA for other reasons, the patient's charts were reviewed, and all patients who received tPA for acute stroke were identified. A total of 121 patients received tPA for acute stroke, out of which 16 patients could not undergo MRI of the brain to confirm the diagnosis because MRI of the brain was either contraindicated or was refused by the patient, and hence were excluded from the final analysis. The final sample size was 105 patients. Out of the 105 patients, 26 (25%) patients were SM. The male-to-female ratio was 1:1. The mean age was 67 years old (range 26-90). The mean total SM score was 2.11. When compared with patients who had real ischemic strokes, those with SM were significantly