Application of the ABCD² Score to Identify Cerebrovascular Causes of Dizziness in the Emergency Department

Babak B. Navi, MD; Hooman Kamel, MD; Maulik P. Shah, MD; Aaron W. Grossman, MD, PhD; Christine Wong, MD; Sharon N. Poisson, MD; William D. Whetstone, MD; S. Andrew Josephson, MD; S. Claiborne Johnston, MD, PhD; Anthony S. Kim, MD, MAS

Background and Purpose—Dizziness can herald a cerebrovascular event. The ABCD² score predicts the risk of stroke after transient ischemic attack partly by distinguishing transient ischemic attack from mimics. We evaluated whether this score would also identify cerebrovascular events among emergency department patients with dizziness.

Methods—We retrospectively identified consecutive adults presenting to a university emergency department with a primary symptom of dizziness, vertigo, or imbalance. Two neurologists independently reviewed medical records to determine whether the presenting symptom was caused by a cerebrovascular event (ischemic stroke, transient ischemic attack, or intracranial hemorrhage). ABCD² scores were then assigned using clinical information from the medical record. The ability of the score to discriminate between patients with cerebrovascular events and those with other diagnoses was quantified using the c statistic.

Results—Among 907 dizzy patients (mean age, 59 years; 58% female), 37 (4.1%) had a cerebrovascular cause, the majority of which were ischemic strokes (n=24). The median ABCD² score was 3 (interquartile range, 3–4). The ABCD² score predicted ultimate diagnosis of a cerebrovascular event (c statistic, 0.79; 95% CI, 0.73–0.85). Only 5 of 512 (1.0%) patients with a score of ≤3 had a cerebrovascular event compared to 25 of 369 patients (6.8%) with a score of 4 or 5 and 7 of 26 patients (27.0%) with a score of 6 or 7.

Conclusions—The ABCD² score may provide useful information on dizzy emergency department patients at low-risk for having a cerebrovascular diagnosis and may aid frontline providers in acute management if validated prospectively. (Stroke. 2012;43:1484-1489.)

Key Words: acute stroke ■ brainstem stroke ■ clinical neurology ■ clinical prediction score ■ dizziness ■ emergency medicine ■ transient ischemic attack

Dizziness is a common patient symptom, accounting for 3.3% of emergency department (ED) visits and $1.1 billion in evaluative costs in the United States annually. Although dizziness is usually attributable to benign etiologies such as peripheral vertigo, up to 5% of acute dizziness cases may be from cerebrovascular disease, which could lead to preventable complications if unrecognized at presentation. Because of this concern, ED evaluations for dizziness are often lengthy and involve substantial use of diagnostic resources such as neuroimaging studies. Better methods to stratify the risk of stroke in dizzy ED patients would allow clinicians to optimize the use of neuroimaging studies, improve diagnostic accuracy, and enhance patient flow through the ED. Current strategies for assessing ED patients with dizziness are inadequate. Many clinicians rely on a symptom quality approach (vertigo, presyncope, disequilibrium, or nonspecific dizziness), which was developed >30 years ago and has limited clinical utility in the ED setting. More recently, specialized oculomotor examinations (head-thrust, gaze-evoked nystagmus, and skew deviation) have been shown in several studies to provide useful diagnostic information when applied by expert neuro-ophthalmologists, and a recent study suggested that neurology residents can accurately apply these highly sensitive and specific techniques after only a few hours of formal training. However, the reliability of these techniques performed by frontline ED clinicians is unknown. Accordingly, a clinical prediction tool that incorporates simple and objective clinical parameters that are readily available at the bedside would be useful for frontline clinicians. In fact, a survey of 1150 emergency physicians found that the top priority for...
developing clinical decision rules in adults was a rule to identify serious causes of vertigo.15

The ABCD² score is a simple, validated, and widely applied clinical prediction tool for assessing the risk of stroke after a transient ischemic attack (TIA).16 The performance of this score is based, in part, on its ability to distinguish TIA from noncerebrovascular mimics.17–19 Therefore, we evaluated the performance of the ABCD² score to identify cerebrovascular causes of dizziness in a large consecutive series of ED patients with a primary triage symptom of dizziness.

Subject and Methods

Study Subjects and Design

We conducted a retrospective observational study to assess the ability of the ABCD² score to stratify the risk of cerebrovascular diagnoses in dizzy patients. We identified consecutive adults with a chief symptom of dizziness, vertigo, or imbalance presenting to the University of California San Francisco Medical Center ED from January 1, 2007 to December 31, 2009. University of California San Francisco is a tertiary care hospital and certified primary stroke center with around-the-clock access to brain MRI and on-site neurology consultation (~38 000 ED visits annually; 22% admitted to hospital). Eligible patients were identified using a free-text search of presenting triage symptoms for the following terms: “dizzy,” “dizziness,” “vertigo,” “spinning,” “imbalance,” or “disequilibrium.” Two neurologists reviewed each medical record and excluded cases in which the primary symptom was unrelated to dizziness (eg, no mention of dizziness or related search terms in the documentation). For patients with multiple ED visits for dizziness during the study period, we included only the initial visit. The University of California San Francisco Institutional Review Board approved this study.

Measurements

Six neurologists (4 vascular neurologists and 2 senior neurology residents) were trained using written study protocols for case selection, chart abstraction, and the assignment of a final diagnosis. For each case, one neurologist was randomly assigned to abstract key patient demographic and clinical data, including associated neurological symptoms, vascular risk factors, vital signs, neurological examination findings, neuroimaging findings, ED treatments, and hospital disposition for each case using a structured data abstraction form. This reviewer would then select a final diagnosis from a prespecified list using all available data including subsequent hospital admissions (if applicable) and all subsequent patient encounters at University of California San Francisco. In cases in which the treating clinicians documented conflicting diagnoses, abstractors considered information from clinicians in the following hierarchy when making their final diagnoses: (1) neurologists; (2) otolaryngologists; and (3) ED physicians. A second neurologist was randomly assigned to review each case to independently assign a final diagnosis, with a third neurologist available to resolve any disagreements. Abstractors were masked to the ABCD² score assigned to each patient. To maximize data quality, periodic meetings of all study neurologists were held to review coding rules and a random 5% sample of all cases was selected for complete reabstraction and review.

The ABCD² score is a clinical prediction score ranging from 0 to 7, which assigns points based on the following 5 clinical factors: age (60 years or older = 1); blood pressure (≥140/90 = 1); clinical features (unilateral weakness = 2; speech disturbance without weakness = 1; any other symptom = 0); duration of symptoms (<10 minutes = 0, 10–59 minutes = 1, ≥60 minutes = 2); and diabetes = 1.16 A modified ABCD² score was assigned to each case during the data analysis phase after all data abstraction was complete. The individual components of the score were compiled from the information contained in separate sections of the abstraction form and the score was not otherwise available to the reviewers during chart abstraction. Because the duration of symptoms was not readily available from chart review, all patients were initially assigned an episode duration of ≥60 minutes, which effectively removes the contribution of this item to the overall score.

The primary outcome was a final diagnosis of a cerebrovascular cause of dizziness, defined as ischemic stroke, TIA, or intracranial hemorrhage. Ischemic stroke was defined as a new neurological deficit lasting >24 hours and no clinical or radiological indication of a nonvascular mimic. TIA was defined as an acute neurological deficit lasting <24 hours, attributable to focal brain ischemia, and without evidence of a nonischemic etiology. Intracranial hemorrhage was defined as the presence of intracerebral, subarachnoid, subdural, or epidural blood apparent on a neuroimaging study.

Statistical Analysis

Descriptive statistics were used to characterize demographic and clinical characteristics of study subjects. We assessed univariate associations between each component of the ABCD² score and the outcome using logistic regression to confirm the contribution of these components to the overall performance of the score. We then assessed the components of the score jointly in a multivariable logistic model.

To evaluate the performance of the ABCD² score, we calculated the risk of a cerebrovascular diagnosis stratified by patients’ ABCD² scores. The areas under the receiver-operator curves (c statistic) and 95% confidence intervals were then generated to assess discrimination performance. Perfect discrimination results in a c statistic of 1.0, whereas discrimination that is no better than chance would result in a c statistic of 0.5. Statistical analyses were performed with Stata (version 11.2; Stata Corporation).

Results

Clinical Characteristics

During the 3-year study period, there were 1907 adult patients with a triage symptom of dizziness or a related search term. After excluding patients in whom dizziness was not a primary symptom, 907 patients (0.8% of all ED encounters) met our eligibility criteria and were included in the final analysis. “Dizzy” or “dizziness” was the most common triage symptom (n=628; 69%), followed by “vertigo” or “spinning” (n=240; 26%) and “imbalance” or “disequilibrium” (n=39; 4%). The mean age was 59 (SD, 19), and 58% were women (Table 1). A substantial fraction (n=321, 35%) of patients were evaluated by neuroimaging, with 252 (28%) head CT and 104 brain MRI (11%) performed; 35 (4%) patients had both studies. Neurological consultation in the ED was frequent (n=180; 20%). Most patients were discharged home (75%). Of those admitted to the hospital (n=204; 22%), 69% were admitted to a telemetry ward (n=127) or an intensive care unit (n=12). In a random sample of 50 patients (5.5% of the cohort), 37 (74%) had another inpatient or outpatient encounter at our institution after the index ED visit included in the chart review. The mean time from index ED visit to the last encounter reviewed was 331 days (median, 246 days; range, 0–1471).

Outcomes

Among ED patients with dizziness, 37 (4.1%; 95% CI, 2.9%–5.6%) had a cerebrovascular cause, of which 24 (65%) were ischemic strokes, 8 (22%) were TIA, and 5 (14%) were intracerebral hemorrhages. There was 98.8% agreement on a cerebrovascular diagnosis between the 2 abstractors, corresponding to a kappa of 0.85.
Compared to patients without cerebrovascular events, patients with cerebrovascular events were typically older, male, had more vascular risk factors, and were more likely to have a triage symptom of “imbalance” or “disequilibrium” or have been using antiplatelet or anticoagulant agents (Table 1).

Modified ABCD² Score Performance

The median modified ABCD² score was 3 (interquartile range, 3–4; Figure 1). Patients with cerebrovascular causes of dizziness had higher ABCD² scores than those with noncerebrovascular diagnoses (Wilcoxon rank-sum test \(P < 0.0001\)). In both univariate and multivariate analysis, all individual components of the ABCD² score with the exception of diabetes and duration of symptoms (which had been removed from the model) were significantly more common in those with cerebrovascular events (Table 2). Only one young patient (younger than 45 years of age) had a cerebrovascular outcome and his ABCD² score was 3; he experienced a cardioembolic ischemic stroke from rheumatic heart disease and atrial fibrillation.

The \(c\)-statistic of the ABCD² score for cerebrovascular causes of dizziness was 0.79 (95% CI, 0.73–0.85; Figure 2). Five of 512 patients (1.0%) with an ABCD² score of \(\leq 3\) had a cerebrovascular event, as opposed to 25 of 369 patients (6.8%) with a score of 4 or 5, and 7 of 26 patients (27.0%) with a score of 6 or 7. All 5 patients with ABCD² scores of \(\leq 3\) who had cerebrovascular diagnoses (4 patients with ischemic strokes and 1 patient with TIA) had ABCD² scores of 3 and at least 2 vascular risk factors. The positive likelihood ratios for ABCD² scores were 1.3 for \(3\), 2.1 for \(4\), 4.4 for \(5\), 8.7 for \(\geq 6\), and 7.8 for \(\geq 7\); the negative likelihood ratios were 0.0 for \(\leq 2\), 0.2 for \(\leq 3\), 0.6 for \(\leq 4\), 0.8 for \(\leq 5\), and 1.0 for \(\leq 6\).

**Table 1. Demographic and Clinical Characteristics of 907 Patients Presenting to the Emergency Department With Dizziness From 2007 to 2009**

<table>
<thead>
<tr>
<th></th>
<th>All (n=907)</th>
<th>Patients With Cerebrovascular Event (n=37)</th>
<th>Patients Without a Cerebrovascular Event (n=870)</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean y (SD)</td>
<td>59 (19)</td>
<td>73 (12)</td>
<td>58 (19)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Women, n (%)</td>
<td>529 (58)</td>
<td>9 (24)</td>
<td>520 (60)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.34</td>
</tr>
<tr>
<td>White</td>
<td>425 (47)</td>
<td>22 (59)</td>
<td>403 (46)</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>246 (27)</td>
<td>12 (32)</td>
<td>234 (27)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>109 (12)</td>
<td>3 (8)</td>
<td>106 (12)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>43 (5)</td>
<td>0 (0)</td>
<td>43 (5)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>84 (9)</td>
<td>0 (0)</td>
<td>84 (10)</td>
<td></td>
</tr>
<tr>
<td>Triage symptom, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Dizzy or dizziness</td>
<td>628 (69)</td>
<td>25 (68)</td>
<td>603 (69)</td>
<td></td>
</tr>
<tr>
<td>Vertigo or spinning</td>
<td>240 (26)</td>
<td>4 (11)</td>
<td>236 (27)</td>
<td></td>
</tr>
<tr>
<td>Imbalance or disequilibrium</td>
<td>39 (4)</td>
<td>8 (22)</td>
<td>31 (4)</td>
<td></td>
</tr>
<tr>
<td>Risk factors, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>447 (49)</td>
<td>32 (86)</td>
<td>415 (48)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Diabetes</td>
<td>131 (14)</td>
<td>6 (16)</td>
<td>125 (14)</td>
<td>0.81</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>251 (28)</td>
<td>21 (57)</td>
<td>230 (26)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>CAD</td>
<td>91 (10)</td>
<td>10 (27)</td>
<td>81 (9)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>CHF</td>
<td>25 (3)</td>
<td>1 (3)</td>
<td>24 (3)</td>
<td>0.99</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>77 (8)</td>
<td>7 (19)</td>
<td>70 (8)</td>
<td>0.03</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>54 (6)</td>
<td>6 (16)</td>
<td>48 (6)</td>
<td>0.02</td>
</tr>
<tr>
<td>Previous TIA</td>
<td>10 (1)</td>
<td>1 (3)</td>
<td>9 (1)</td>
<td>0.34</td>
</tr>
<tr>
<td>Current smoker</td>
<td>70 (8)</td>
<td>4 (11)</td>
<td>66 (8)</td>
<td>0.52</td>
</tr>
<tr>
<td>Medications, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antiplatelet agents</td>
<td>212 (23)</td>
<td>15 (41)</td>
<td>197 (23)</td>
<td>0.02</td>
</tr>
<tr>
<td>Anticoagulants</td>
<td>55 (6)</td>
<td>6 (16)</td>
<td>49 (6)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

CAD indicates coronary artery disease; CHF, congestive heart failure; DBP, diastolic blood pressure; SBP, systolic blood pressure; SD, standard deviation; TIA, transient ischemic attack.

**Discussion**

In a large cohort of patients presenting to the ED with dizziness, the ABCD² score effectively identified a group of patients at particularly low risk for an underlying cerebrovascular cause, with only 5 of 512 patients with a modified ABCD² \(\leq 3\) having a cerebrovascular diagnosis. Although clinical use of this risk score will require prospective validation and is not intended to supersede clinical judgment—for example, if there is suspicion for a vertebral artery dissection in a young patient with an otherwise low score—these results...
suggest that it may be possible to develop a risk score for dizziness to help streamline evaluations and target costly testing, consultation, and observation to the most appropriate patients. Formal validation and refinement of the risk score and a dedicated assessment of the value of information added and potential impacts on clinical practice will be the subject of future prospective studies.

Dizziness is the neurological symptom most often associated with a missed diagnosis of stroke in the ED, and nearly half of stroke patients report dizziness symptoms in some form. Patient descriptions of the quality of dizziness are notoriously vague, inconsistent, and unreliable. In addition, ED physicians are often overly reliant on the traditional symptom quality approach, may harbor misconceptions about the bedside evaluation of dizzy patients, and may overinterpret the value of head CT scans, which are insensitive for posterior circulation stroke.

Given these issues, some neuro-otologists have recommended moving away from the classical symptom quality approach and instead concentrating on more reliable components of the history, such as triggers, duration, and vascular risk factors, and augmenting the history with sophisticated oculomotor examinations. A normal head-thrust test, gaze-evoked nystagmus, and skew deviation all have been shown to differentiate central from peripheral causes of vertigo, with one prospective study finding that the combination of the 3 tests performed by a neuro-ophthalmologist to be more sensitive than acute MRI for stroke. In addition, 1 recent study demonstrated that neurology residents could apply these techniques after only a few hours of formal instruction to accurately identify posterior circulation strokes in 24 patients with acute vertigo. However, these neuro-ophthalmological examinations have not yet been tested in non-neurologists, and thus the generalizability of these promising bedside techniques to ED and internal medicine clinicians remains uncertain.

To address these concerns, we applied the ABCD² score to dizzy patients to differentiate cerebrovascular from noncerebrovascular causes of dizziness because the ABCD² score utilizes reliable historical variables and simple examination findings, is already familiar to many ED clinicians, and has been validated in numerous heterogeneous cohorts. Although ABCD² was initially created as a prognostic score to stratify the risk of subsequent stroke in patients with TIA, previous studies have shown that its performance is partially explained by its ability to identify patients with true TIA. Similarly, recent studies have found higher ABCD² scores to be associated with carotid stenosis on carotid duplex, diffusion-weighted imaging evidence of infarction on brain MRI, and minor ischemic strokes. The ABCD² score was developed and validated specifically for cerebrovascular outcomes. Most of its individual
components (eg, age, elevated blood pressure, diabetes mellitus) are risk factors for vascular conditions but may not be risk factors for other serious neurological diagnoses such as brain tumors or demyelinating disease. Therefore, we focused our study on cerebrovascular diagnoses, which account for most central neurological causes of dizziness3 and may be particularly relevant for ED evaluations that are driven by the need to adequately evaluate for posterior circulation stroke.5

Previous studies have documented a striking secular trend in the use of neuroimaging studies to evaluate dizziness in the ED without a corresponding increase in the proportion of dizzy ED patients with stroke diagnosed.6 In 1995, <10% of dizzy ED patients were sent for a neuroimaging study, but by 2004 this figure was >25%, a 169% increase. There is also a high degree of practice variation in the use of neuroimaging studies across ED without corresponding improvements in overall diagnostic yield for stroke.25 These findings suggest that a validated clinical risk score may provide a way to identify patients with a sufficiently low risk for stroke to justify streamlining the evaluation by deferring or eliminating a neuroimaging study or consultation altogether, which is the subject of a planned follow-up prospective study.

Our results should be interpreted in the context of several limitations. First, our study was limited to a single tertiary care referral center with around-the-clock access to neuroimaging and on-site neurology consultation. Accordingly, our results may not be generalizable to other practice settings and will require external validation before clinical use. Second, final patient diagnoses were ascertained from chart review and specific features of dizziness (eg, triggers) may have been incompletely examined or documented by the treating clinician. Third, diagnostic evaluations were not uniform, so our follow-up data for review were variable and incomplete. Thus, some patients may have been misdiagnosed and clinical information required to correct the diagnosis otherwise would not be available in the chart. Therefore, the data likely better-reflect the specificity rather than sensitivity of the ABCD2 score to screen stroke patients. Fourth, it is possible that components of risk score were incorporated into the decision-making by providers to decide which patients to image with MRI or in decisions by abstracting neurologists on the ultimate cerebrovascular diagnosis, thus overestimating the performance of the score. Fifth, because of inconsistent ED documentation and dizzy patients’ poor characterization of their syndromes,8 we were unable to abstract the duration of patient episodes and assign each patient a duration of ≥60 minutes. It is possible that prospective collection of the duration element of the score could change the performance of the model. However, a recent study assessing the diagnostic utility of the ABCD2 score to distinguish TIA and minor ischemic strokes from noncerebrovascular processes found duration of symptoms contributes little additional discriminatory information.19 Next, the usefulness of this score for nonvascular etiologies has not been formally assessed because our analysis was limited to serious vascular etiologies. Finally, the diagnosis of a cerebrovascular event is based partly on clinical examination findings (ie, C of ABCD2) and vascular risk factors (ie, A, B, and D of ABCD2). Our study is unable to directly determine if applying the score prospectively will enhance diagnostic accuracy or resource allocation; however, the value of a clinical risk score is based on its ability to combine information from standardized and objective clinical factors together to provide clinicians with more precise estimates of the probability of a particular outcome.

**Conclusions**

A modified ABCD2 score shows promise as a simple and easily applied tool for distinguishing cerebrovascular from noncerebrovascular causes of dizziness in patients presenting to the ED. Future prospective studies are required to validate these results before applying this score at the bedside.

**Sources of Funding**

This study was supported by an award from the American Heart Association.

**Disclosures**

Drs Johnston (modest) and Kim (significant) received research support from the American Heart Association for this project.

**References**


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(Stroke. 2012;43:1484-1489.)

Key Words: acute stroke □ brainstem stroke □ clinical neurology □ clinical prediction score □ dizziness □ emergency medicine □ transient ischemic attack

Table 2. Univariate and Multivariate Association of ABCD² Score Components With Cerebrovascular Outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>n (%)</th>
<th>Univariate Odds Ratio (95% CI)</th>
<th>Multivariate Model Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 60 y or older</td>
<td>465 (51)</td>
<td>6.5 (2.5–16.7)</td>
<td>5.1 (1.9–13.6)</td>
</tr>
<tr>
<td>BP ≥140/90 mm Hg</td>
<td>515 (57)</td>
<td>4.1 (1.7–10.0)</td>
<td>2.9 (1.2–7.3)</td>
</tr>
<tr>
<td>Clinical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speech disturbance</td>
<td>28 (3)</td>
<td>5.9 (1.9–18.5)</td>
<td>6.2 (1.9–20.4)</td>
</tr>
<tr>
<td>Unilateral weakness</td>
<td>38 (4)</td>
<td>12.7 (5.5–29.2)</td>
<td>10.9 (4.6–26.0)</td>
</tr>
<tr>
<td>Duration*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10 min</td>
<td>0 (0)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>10–59 min</td>
<td>0 (0)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>≥60 min</td>
<td>907 (100)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Diabetes</td>
<td>131 (14)</td>
<td>1.2 (0.5–2.8)</td>
<td>0.7 (0.3–1.9)</td>
</tr>
</tbody>
</table>

BP indicates blood pressure; CI, confidence interval; NA, not available.

*Since duration information was not readily available, all patients were assigned a duration score of ≥60 min, thus effectively removing this variable from the model.