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. The majority of which were ischemic strokes. The ABCD² score predicted ultimate diagnosis of a cerebrovascular event (c statistic, 0.79; 95% CI, 0.73–0.85). Only 5 of 512 patients (1.0%) 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.

Key Words: acute stroke ▪ brainstem stroke ▪ clinical neurology ▪ clinical prediction score ▪ dizziness ▪ emergency medicine ▪ transient ischemic attack
developing clinical decision rules in adults was a rule to identify serious causes of vertigo.\textsuperscript{15} The ABCD\textsuperscript{2} score is a simple, validated, and widely applied clinical prediction tool for assessing the risk of stroke after a transient ischemic attack (TIA).\textsuperscript{16} The performance of this score is based, in part, on its ability to distinguish TIA from noncerebrovascular mimics.\textsuperscript{17–19} Therefore, we evaluated the performance of the ABCD\textsuperscript{2} 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 ABCD\textsuperscript{2} 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 neurologic 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: (1) neurologists; (2) otolaryngologists; and (3) ED physicians. A second neurologist was randomly assigned to each case to independently assign a final diagnosis, with a third neurologist available to resolve any disagreement. We conducted a retrospective observational study to assess the ability of the ABCD\textsuperscript{2} 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.

#### Statistical Analysis

Descriptive statistics were used to characterize demographic and clinical characteristics of study subjects. We assessed univariate associations between each component of the ABCD\textsuperscript{2} 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 ABCD\textsuperscript{2} score, we calculated the risk of a cerebrovascular diagnosis stratified by patients’ ABCD\textsuperscript{2} 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 was 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 ≤3 had a cerebrovascular diagnosis, 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 ≤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 ≥6, and 7.8 for ≥7; the negative likelihood ratios were 0.0 for ≤2, 0.2 for ≤3, 0.6 for ≤4, 0.8 for ≤5, and 1.0 for ≤6.

**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 ≤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 dizziness and may be particularly relevant for ED evaluations that are driven by the need to adequately evaluate for posterior circulation stroke.

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. 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. 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, we were unable to abstract the duration of patient episodes and assigned 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. 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.

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Disclosures
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References


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

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

배경과 목적
어지럼증은 뇌혈관사건의 전조일 수 있다. ABCD² 점수는 일차성형혈관과 이와 유사한 현상을 구분함으로써 일차성형혈
발작 이후 환자의 뇌졸중 위험도를 예측할 수 있다. 저자들
은 이 점수가 응급실에서 어지럼증으로 내원한 환자들에서 얼마나
뇌혈관사건을 예측할 수 있는지를 평가하였다.

방법
저자들은 어지럼증, 혈증 및 불균형이 일차증상으로 일게 대학
병원 응급실에서 내원한 1년간의 환자들을 후향적으로 조사하였
다. 두 명의 신경과 의사가 독립적으로 의무기록을 수집하여
이들 증상이 뇌혈관사고(뇌혈관뇌졸중, 일차성형혈관, 혹은 두
개내출혈)에 기인한 것인지를 확인하였다. 이후 의무기록의
임상자료를 분석하여 ABCD² 점수가 계산되었다. 뇌혈관사고
와 그렇지 않은 환자들을 구분할 수 있는 결과가 얼마나 효과
적인지에 대해서는 c statistics를 이용하여 정량화 되었다.

결과
907명(평균 나이 59세; 58% 여성)의 어지럼증 환자들 중 37명
(4.1%)의 환자들이 뇌혈관조직에 기인한 어지럼증이었으며, 이들 중 다수가 뇌혈관뇌졸중(24명)이었다. ABCD² 점수의 중앙값
은 3점(사분위수 범위, 3~4)이었다. ABCD² 점수는 뇌혈관사
건을 정확히 예측하였다(c statistics, 0.79; 95% CI, 0.73~
0.85). 512명의 환자 중에서 3점 이상인 경우 5명(1.0%)만이
뇌졸중 환자로 확인된 반면, 4점과 5점인 환자들에는 6.8%
(25/369명), 또한 6점과 7점에서는 27% (7/26명)의 환자들이
뇌졸중으로 확인되었다.

결론
ABCD² 점수는 응급실에 어지럼증으로 내원한 환자들에게 뇌
졸중 위험도에 대한 유용한 정보를 제공할 수 있다. 또한 이 점
수가 전향적으로 타당성이 입증됨에 긍정적 기저에 있어 최
선의 도움을 제공할 수 있을 것이다.

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

<table>
<thead>
<tr>
<th></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>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>4.1 (1.7–10.0)</td>
<td>2.9 (1.2–7.3)</td>
</tr>
<tr>
<td>Clinical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speech disturbance</td>
<td>5.9 (1.9–18.5)</td>
<td>6.2 (1.9–20.4)</td>
</tr>
<tr>
<td>Unilateral weakness</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>
</tr>
<tr>
<td>&lt;10 min</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>10–59 min</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>≥60 min</td>
<td>907 (100)</td>
<td>NA</td>
</tr>
<tr>
<td>Diabetes</td>
<td>131 (14)</td>
<td>1.2 (0.5–2.8)</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.

Figure 2. Receiver-operator characteristic curve of the ABCD² score to predict cerebrovascular diagnoses in 907 emergency department patients with dizziness.