ABCD2 Scores and Prediction of Noncerebrovascular Diagnoses in an Outpatient Population
A Case–Control Study

Terence J. Quinn, MRCP; Alan C. Cameron, BSc(Hons); Jesse Dawson, MRCP; Kennedy R. Lees, MD; Matthew R. Walters, MD

Background and Purpose—Among patients with transient ischemic attack, the ABCD2 score predicts short-term stroke risk. Use of the ABCD2 score assumes the underlying diagnosis to be transient ischemic attack; however, most transient ischemic attack services assess a variety of diagnoses. We hypothesized that patients with low ABCD2 score predominantly have noncerebrovascular diagnoses.

Methods—Our transient ischemic attack clinics assess all suspected cerebrovascular events referred. Comprehensive clinical and investigation details are prospectively recorded. We collated data for patients seen between August 1992 and January 2005 inclusive. We calculated ABCD2 scores and compared proportions of noncerebrovascular diagnoses for each ABCD2 grade using $\chi^2$ analysis. We ran similar analyses for atrial fibrillation, vascular lesions on brain imaging, and carotid stenosis. We calculated positive predictive value of low (0 to 1) ABCD2 score for noncerebrovascular diagnosis and described properties of ABCD2 as a diagnostic tool using receiver operating characteristic curves.

Results—We derived ABCD2 scores for 3646 patients of whom 1769 had a noncerebrovascular diagnosis. There was a positive association between increasing ABCD2 score and cerebrovascular diagnosis ($P<0.001$). Higher ABCD2 score was associated with vascular lesions on brain imaging ($P<0.001$) and moderate–severe carotid disease ($P<0.001$) but not atrial fibrillation ($P=0.097$). The positive predictive value of low ABCD score was 0.81 for noncerebrovascular diagnosis and 0.93 for negative imaging. Receiver operating characteristic curve analysis suggested reasonable accuracy (area under the curve, 0.745).

Conclusion—For low scores, ABCD2 may assist in selecting out noncerebrovascular diagnoses. However, this approach will potentially misclassify many true transient ischemic attacks. Further refinement would be needed before clinical application. (Stroke. 2009;40:749-753.)

Key Words: ABCD score ■ ABCD2 score ■ atrial fibrillation carotid stenosis ■ early diagnosis ■ stroke ■ transient ischemic attack

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transient ischemic attack (TIA) is increasingly recognized as a medical emergency with 7-day stroke risk as high as 30% in certain groups. Clinical prediction tools have been developed to aid risk stratification after TIA. The “ABCD” scoring tool and its refinement, “ABCD2,” attempt to quantify risk using clinical features and describe an ordinal hierarchical scale of risk from 0 to 6/7 (Table 1). Those with highest scores have significantly increased risk of early stroke.

Although popular, there remains some controversy regarding application of the scale. Attempts to validate ABCD-based scoring in independent populations have been generally, but not universally, successful. Some groups have questioned the usefulness of a score that does not incorporate significant carotid disease or other potential cardioembolic source. More importantly, in all ABCD validation exercises, the underlying diagnosis has been assumed to be TIA. This does not reflect clinical practice. Studies of TIA assessment services suggest a consistently high referral rate for noncerebrovascular pathologies. The difficulty of making an accurate initial TIA diagnosis is well recognized, even among stroke specialists, because many as one fifth of patients initially thought to have stroke transpire to have an alternative diagnosis. The majority of studies testing the properties of ABCD did not make use of brain imaging to confirm ischemic brain damage, and thus it seems likely that the cohorts described included a substantial proportion of noncerebrovascular diagnoses.

In the ABCD studies, patients defined as low risk had a negligible event rate during extended follow-up. A possible explanation is that at low scores, the tool operates to
distinguish true TIA from other more benign pathologies. If this is the case, then the clinical usefulness of ABCD is 2-fold: at higher scores, patients at risk can be identified and have evidence-based treatment expedited, whereas at the lower scores, the clinician can be alerted to the possibility of a noncerebrovascular diagnosis and investigate accordingly. A diagnostic use of ABCD2 seems intuitive because certain components, namely clinical presentation and symptom duration, are likely to discriminate against common stroke mimics and are used in established diagnostic tools. This is an important property to clarify, because stroke services are increasingly using ABCD to triage new referrals.

We hypothesized that noncerebrovascular diagnoses would be overrepresented in patients with low ABCD2 score referred to an outpatient TIA service and that prevalence of vascular lesion on brain imaging, carotid disease, and atrial fibrillation (AF) would all be lower in these patients.

**Methods**

Our university hospital outpatient TIA service serves a typical urban population and assesses all suspected cerebrovascular events referred with no age or functional limitations. No patients are refused assessment on the grounds of low probability of TIA. For each patient encounter, we prospectively record demographic, clinical, and investigation details in a comprehensive database, the West Glasgow Stroke Registry. Institutional guidelines are followed for informing patients about data collection; all stored data are anonymized before analysis in line with local ethics and European data protection guidelines.

Data were collated for patients seen between August 1992 and January 2005 inclusive; the stroke registry holds data on all stroke unit inpatients and clinic encounters. For this study, analysis was restricted to patients seen in the clinic only. From the available data, we extracted age at presentation, blood pressure recorded during consultation, clinical features of the event, and duration of symptoms. Presence of diabetes was defined as a previous diagnosis of diabetes or random serum glucose of $\geq 11.1$ mmol/L.

We derived ABCD2 scores for 3646 with a high number of patients with older age and high blood pressure. This was driven by a high number of patients at risk using the scoring criteria. This was performed similar analyses for presence of AF, significant carotid disease, and vascular lesions on brain imaging. We calculated positive predictive value of low ABCD2 score for noncerebrovascular diagnosis, dichotomizing ABCD2 at 2 predefined levels 0 to 1 and 0 to 2. All statistical analyses were performed using Minitab software (Version 14; Minitab Inc.). To further describe diagnostic properties of ABCD2, we calculated areas under receiver operating characteristic (ROC) curve for noncerebrovascular diagnosis. ROC curves were calculated across all possible ABCD2 scores and was performed using SPSS software (SPSS Version 15.0; SPSS Inc, Chicago, IL).

**Results**

Of the 3705 patients in the West Glasgow Stroke Registry, we were able to derive ABCD2 scores for 3646 with a median (interquartile range) age of 67 (56 to 75) years; 1897 (54.5%) were female. Comparison of the cerebrovascular and noncerebrovascular diagnostic cohorts revealed increased prevalence of traditional cardiovascular risk factors in the group thought to have sustained a “true” event (Table 2). Almost half of the patients assessed at the clinic (1709 patients [46.9%]) were defined as moderate–high risk using the scoring criteria. This was driven by a high number of patients with older age and high blood pressure (Table 3).

Noncerebrovascular diagnosis was recorded in 1769 patients (48.5%). The most commonly encountered stroke mimics were syncope, migraine, and seizure (Table 4), although a wide variety of other diagnoses were recorded. There was a positive association between increasing ABCD2 score and true cerebrovascular diagnosis ($P<0.001$).

A total of 185 patients (5.1%) had evidence of AF, whereas Doppler evidence of significant (moderate–severe) carotid disease was documented in 291 patients.
ABCD2 was associated with significant carotid disease \( (P<0.001) \) but not with AF \( (P=0.097) \). Brain imaging was performed on 1693 patients \( (46.4\%; \text{CT}: 999; \text{MRI}: 727; \text{both}: 33) \). Among these, 666 patients \( (39.3\%) \) had radiological evidence of cerebrovascular disease. For those patients with available imaging, higher ABCD2 was associated with the presence of vascular lesions on brain imaging \( (P<0.001) \).

The positive predictive value of ABCD2 dichotomized at 0 to 1 score was 0.81 for noncerebrovascular diagnosis and 0.93 for negative imaging; corresponding sensitivity was 27.8% and specificity 93.7%. ABCD2 dichotomized at 0 to 2 gave a positive predictive value of 0.74 for noncerebrovascular diagnosis and 0.93 for negative imaging; corresponding sensitivity was 52.6% and specificity 82.8%.

Analysis of the ROC curve for use of ABCD2 in the diagnosis of noncerebrovascular events suggests reasonable accuracy with area under the curve of 0.745 \( (95\% \text{ CI}, 0.729 \text{ to } 0.761) \); Figure). A tradeoff between sensitivity and specificity did not suggest an optimal ABCD2 score as a cutoff for prediction of noncerebrovascular diagnosis.

**Discussion**

Despite increasing use of ABCD2 to “triage” referrals to TIA services, the properties of the scale as a diagnostic tool have not previously been described. We have shown that the “ABCD2” scores can function as a crude diagnostic aid, separating cerebrovascular disease from other pathologies. However, as seen on ROC analysis, limitations in specificity and sensitivity may preclude its use in clinical practice.

### Table 3. Clinical Features of TIA Clinic Patients According to ABCD2 Scoring Criteria

<table>
<thead>
<tr>
<th>Cerebrovascular Disease, n (%; n=1877)</th>
<th>Noncerebrovascular Disease, n (%; n=1769)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ≥60 years</td>
<td>1378 (73.4)</td>
</tr>
<tr>
<td>Blood pressure ≥140/90 mm Hg</td>
<td>1334 (71.1)</td>
</tr>
<tr>
<td>Clinical: unilateral weakness</td>
<td>1031 (54.9)</td>
</tr>
<tr>
<td>Clinical: speech disturbance</td>
<td>452 (24.1)</td>
</tr>
<tr>
<td>Duration ≥60 minutes</td>
<td>991 (52.8)</td>
</tr>
<tr>
<td>Duration 10–59 minutes</td>
<td>407 (21.7)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>170 (9.1)</td>
</tr>
</tbody>
</table>

\( (7.9\%) \), ABCD2 was associated with significant carotid disease \( (P<0.001) \) but not with AF \( (P=0.097) \). Brain imaging was performed on 1693 patients \( (46.4\%; \text{CT}: 999; \text{MRI}: 727; \text{both}: 33) \). Among these, 666 patients \( (39.3\%) \) had radiological evidence of cerebrovascular disease. For those patients with available imaging, higher ABCD2 was associated with the presence of vascular lesions on brain imaging \( (P<0.001) \).

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### Table 4. Most Common Noncerebrovascular Diagnosis Made at the TIA Clinic (Absolute No. and Proportion of All Noncerebrovascular Diagnosis)

<table>
<thead>
<tr>
<th>Noncerebrovascular Diagnosis</th>
<th>Frequency of Attendance at TIA Clinic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syncope</td>
<td>145 (7.7%)</td>
</tr>
<tr>
<td>Migraine</td>
<td>63 (3.4%)</td>
</tr>
<tr>
<td>Seizure</td>
<td>48 (2.6%)</td>
</tr>
<tr>
<td>Transient global amnesia</td>
<td>42 (2.2%)</td>
</tr>
<tr>
<td>Labyrinthitis</td>
<td>17 (0.9%)</td>
</tr>
<tr>
<td>Peripheral nerve lesion</td>
<td>12 (0.6%)</td>
</tr>
</tbody>
</table>

Some groups have criticized the ABCD scores because they are based purely on clinical features and take no account of investigations. This argument is only valid if investigations can meaningfully add to the clinical assessment. In our outpatient cohort, ABCD was predictive of a vascular lesion on imaging and predicted potential carotid but not cardiac embolic sources. The imaging results are likely biased because only a proportion of patients proceed to CT or MRI with the selection based on clinical features, which include those used to calculate the ABCD2 score; however, the positive relationship between ABCD2 and pathology on imaging does add further support to usefulness of ABCD as a diagnostic tool. We were unable to include carotid Doppler data for every patient included in the analysis. Although Doppler assessment is routine for all patients referred, complete Doppler assessment of this population is perhaps unrealistic in a clinical setting because patients may default from imaging or have imaging performed at another center. However, there was no significant difference between proportions imaged in the cerebrovascular and noncerebrovascular group and, as such, we feel our conclusions remain valid.

The lack of a significant relationship between AF and ABCD2 is surprising. Rates of AF are lower in our cohort than would be expected, and it is possible that there is a degree of case ascertainment bias. We do not regularly make use of prolonged cardiac monitoring to define potential arrhythmia and interpretation of electrocardiogram is by the referring clinician alone. With AF prevalence of only 5% in our cohort, statistical power to detect a significant association will be lower than for carotid
disease. Other groups have reported a similar relationship between ABCD and potential embolic source, but results were weakened by insufficient statistical power.\(^{11}\)

Although the positive association between low ABCD2 score and noncerebrovascular diagnosis would suggest diagnostic usefulness, analysis of ROC curves reveals only reasonable sensitivity at a price of poor specificity. If ABCD2 is to be used to triage referrals to fast-track stroke services, the ideal would be to not include any true stroke within the noncerebrovascular cohort at the expense of “contamination” of the stroke group with nonstroke pathologies.

A strength of our analysis is the large number of patients included; our total cohort is considerably larger than previous published ABCD studies. In our cohort, there were few examples of unavailable data and so it seems unlikely that incomplete coding would systematically bias the final results. To achieve large numbers in a single-center study requires a substantial time investment and our analysis describes 12.5 years of TIA assessment. We do not consider that temporal variation will bias our results, because overall caseload of the unit and composition of the senior stroke team did not change during the study period. Our analysis was restricted to one catchment area within a city; however, our TIA service and patient population are typical of an urban UK clinic\(^{12}\) and, as such, results should be generalizable.

During the time period of this retrospective analysis, attitudes and models regarding stroke care have changed dramatically. These changes should not meaningfully affect the primary aims of our study; our stroke service has always aimed for timely and comprehensive assessment of all suspected stroke and despite changes in investigational techniques, the validity of clinical diagnosis of stroke will not have altered. More recently, an evidence base for immediate access TIA assessment remains uncommon. The heterogeneous cohort of patients included in our analysis may differ from patients seen in these contemporary immediate access services. However, although such services remain infrequent, our patient group is likely representative of a cohort seen in the majority of outpatient stroke services.

Some aspects of our methodology require discussion. In our cohort, diagnosis of TIA was, and remains, essentially clinical. We recognize that increasingly sophisticated imaging techniques can determine brain ischemia in a large proportion of patients with TIA.\(^{13}\) However, use of imaging to define TIA remains controversial and many still accept expert clinical diagnosis as the gold standard. Although arbitrary, our definition of TIA should be consistent; the same standard evaluation is performed for all patients and final diagnosis is in consultation with permanent senior staff. The diagnostic accuracy of our clinic-based assessment is further supported by a recent observational outcomes analysis, in which vascular events were significantly increased in our TIA service patients thought to have cerebrovascular disease.\(^{14}\)

Our derived ABCD2 scores could potentially differ from ABCD2 scoring as originally described. Our definition of diabetes was more inclusive than previous definitions, whereas measure of blood pressure after delay to clinic presentation may underestimate blood pressure in the immediate period postevent. Our outpatient service has not always offered same-day assessment for all suspected TIAs and so a proportion of the highest-risk TIAs may have been missed because they went on to develop a stroke event before assessment. In theory, patients’ recall of their index stroke event may alter in the time they wait for assessment and thus bias the “clinical” and “duration” components of the score. Such an argument holds for all but the very uncommon 24-hour-a-day 7-day-a-week services; in the absence of any supportive data, the counter-argument could equally be made that in the “stress” of the acute event patient’s description of symptomatology may be less accurate than after a period of time for reflection. Other TIA risk stratification scores exist.\(^{15,16}\) We chose to focus on ABCD2 due to its relative simplicity, extensive validation, and widespread clinical use. However, our finding that ABCD2 may act to distinguish noncerebrovascular diagnoses will likely apply to other triage scales, because they share several common features.

The implications of our findings for the practicing stroke clinician are less clear. ABCD2 is increasingly being used to stratify referrals to fast-track clinics.\(^{9}\) Although as a group, patients with low ABCD2 scores have significantly less true cerebrovascular disease, there are still enough true TIA cases that this group cannot be considered “benign” and still require prompt assessment and management. At present, all we can conclude is that patients referred to a cerebrovascular service with a low ABCD2 score are more likely to have noncerebrovascular diagnoses than patients with a higher score and, as such, investigations should include a broader set of differentials. Prospective studies examining diagnoses and outcomes of patients triaged with ABCD2 could help better define the use of the scale in clinical practice. However, based on our data, we would urge caution in reliance on scoring systems without corresponding clinical assessment.

Disclosures

None.

References

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