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Original Paper

High ABCD^2 Scores and In-Hospital Interventions following Transient Ischemic Attack

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Key Words
Transient ischemic attack · Acute stroke

Abstract
Background and Purpose: Following transient ischemic attack (TIA), there is increased risk for ischemic stroke. The American Heart Association recommends admission of patients with ABCD^2 scores ≥3 for observation, rapid performance of diagnostic tests, and potential acute intervention. We aimed to determine if there is a relationship between ABCD^2 scores, in-hospital ischemic events, and in-hospital treatments after TIA admission. ***Methods:*** We reviewed consecutive patients admitted between 2006 and 2011 following a TIA, defined as transient focal neurological symptoms attributed to a specific vascular distribution and lasting <24 h. Three interventions were prespecified: anticoagulation for atrial fibrillation, carotid or intracranial revascularization, and intravenous or intra-arterial reperfusion therapies. We compared rates of in-hospital recurrent TIA or ischemic stroke and the receipt of interventions among patients with low (<3) versus high (≥3) ABCD^2 scores. ***Results:*** Of 249 patients, 11 patients (4.4%) had recurrent TIAs or strokes during their stay (8 TIAs, 3 strokes). All 11 had ABCD^2 scores ≥3, and no neurological events occurred in patients with lower scores (5.1 vs. 0%; p = 0.37). Twelve patients (4.8%) underwent revascularization for large artery stenosis, 16 (6.4%) were started on anticoagulants, and no patient received intravenous or intra-arterial

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reperfusion therapy. The ABCD^2 score was not associated with anticoagulation (p = 0.59) or revascularization (p = 0.20). ***Conclusions:*** Higher ABCD^2 scores may predict early ischemic events after TIA but do not predict the need for intervention. Outpatient evaluation for those with scores <3 would potentially have delayed revascularization or anticoagulant treatment in nearly one-fifth of 'low-risk' patients.

Background and Purpose

Transient ischemic attack (TIA) is associated with increased risk for subsequent stroke. The initial 48 h following TIA are especially of high risk, with estimates of stroke incidence ranging from 1.4 to 9.9% [1]. A prospective population-based study of stroke following TIA further quantified the 6-, 12-, and 24-hour risks of stroke following TIA as 1.2, 2.1, and 5.1%, respectively [2]. In patients who had a stroke within 30 days of their first TIA, about half of the strokes occurred within the first 48 h [3, 4], emphasizing the importance of early triage decision-making. Multiple tools have been used to help assess and stratify a patient's risk for subsequent stroke, including the ABCD^2 score, diffusion-weighted imaging (DWI), and neurovascular imaging [5]. The ABCD^2 score can be quickly calculated and inform emergency department (ED) decision-making. Although validation studies of the ABCD^2 score have produced inconsistent results relating to its predictive value, it remains the simplest and most commonly used tool to evaluate TIA patients in the ED [5–7, 8]. Currently, the American Heart Association/American Stroke Association (AHA/ASA) guidelines state that it is reasonable to admit patients presenting within 72 h of symptom onset who have an ABCD^2 score ≥3, as they may be at higher risk for impending stroke; these guidelines also allow for consideration of admission of patients with lower scores and signs of focal ischemia or the inability to have workup completed in an expedited manner [9]. Those with scores <3 may be at lower stroke risk and could alternately be evaluated rapidly with improved cost-effectiveness in outpatient clinics [10, 11]. However, the role of the ABCD^2 score in predicting the need for acute interventions, such as revascularization and anticoagulation, is less established [12]. Some investigators have found that patients with low scores have an equal risk of subsequent stroke [13]. In particular, ABCD^2 scores may not accurately predict clinically significant carotid stenosis [14]. Therefore, we investigated whether the ABCD^2 score predicted in-hospital events and interventions including recurrent ischemia, thrombolysis, carotid and intracranial revascularization procedures, and initiation of anticoagulation for atrial fibrillation. Our objective was to determine if the ABCD^2 score was an effective way to triage patients presenting to the ED with symptoms concerning for TIA based on the occurrence of in-hospital deterioration, the subsequent occurrence of management changes, or the need for in-hospital interventions.

Methods

Patients

This cross-sectional retrospective study was performed with approval from the institutional research board. All patients hospitalized at our institution, a teaching hospital which was a primary stroke center at the time of this study, with a diagnosis of TIA between August 2006 and March 2011 were prospectively entered into a registry and included in this study; data collection was done by the study authors. TIA was defined as transient focal neurological symptoms attributed to a specific vascular distribution and lasting less than 24 h [15]. All patients suspected of having TIA within the ED are first evaluated by an emergency physician

and subsequently by a neurology resident, and are admitted to the stroke inpatient service while undergoing diagnostic workup. All TIAs were diagnosed by vascular board-certified neurologists, and all patients discharged with a diagnosis of TIA were captured by our registry. Patients who were initially admitted with possible TIA or stroke but not discharged with either diagnosis were systematically excluded from the registry. A CT of the brain was obtained for all patients at the time of admission, and advanced imaging (such as MRI) was obtained for patients without contraindications. Although a newer definition of TIA incorporates MRI findings and classifies restricted diffusion lesions as representing a stroke instead of a TIA, for the purpose of our study, patients with DWI lesions but resolution of symptoms within 24 h were considered TIAs. Additional diagnostic evaluations were at the discretion of the admitting physician, but typically included vascular imaging of the cervical carotid arteries, a transthoracic echocardiogram, telemetry, and additional Holter monitoring. Demographics, type and duration of clinical symptoms, initial National Institutes of Health Stroke Scale (NIHSS) score, medical comorbidities, in-hospital treatments including initiation of intravenous or intra-arterial thrombolysis, large artery revascularization, and anticoagulation were collected. Results of carotid ultrasounds, CT angiogram of the neck, and MR angiogram of the neck were reviewed to determine if there was a >50% stenosis on the symptomatic side. An ABCD^2 score was calculated for each patient by the primary study physician based on clinical data available in the patient's chart [7]. Patients initially admitted for possible TIA but later determined to have an alternate diagnosis were excluded from our study.

Events

The primary outcome measure was in-hospital ischemic events, defined as a return of previously resolved symptoms or new focal neurological symptoms. Patients were considered to have had an ischemic stroke if follow-up MRI or CT confirmed new areas of ischemia not previously present, with persistent clinical symptoms lasting >24 h and to have recurrent TIA if symptoms lasted ≤24 h. Secondary outcome measures included all in-hospital intervention as detailed below. In-hospital use of intravenous tissue plasminogen activator and/or endovascular reperfusion therapy (i.e. intra-arterial lytic or mechanical embolectomy) was ascertained. Revascularization of symptomatic arterial stenosis was defined as either endarterectomy or angioplasty/stenting of an extracranial internal carotid artery or angioplasty/stenting of an intracranial artery. Anticoagulation was defined as initiation of intravenous or oral anticoagulation during hospitalization or at discharge (i.e. heparin, warfarin, or novel anticoagulants). In-hospital intervention plus in-hospital ischemic events were combined to form a composite risk in order to more fully understand events following the index symptoms.

Statistical Analysis

Patients' ABCD^2 scores were dichotomized into low risk and high risk. Low risk was defined as having a score <3 and high risk as having a score ≥3. χ^2 or Fisher's exact tests were used to examine the relationship between demographics, clinical features, DWI positivity, and ABCD^2 category on (1) the occurrence of in-hospital recurrent TIA or stroke and (2) in-hospital treatments. A p value ≤0.05 was considered significant in all analyses. Data analysis was performed using SPSS 16.0 (Chicago, Ill., USA).

Results

Two hundred and 49 patients were admitted for TIA during the study period; 45% were male, with a mean age of 64 years (range 18–97), and 47% were Caucasian. The mean length of stay was 2.6 days (median 2), and most patients (94%) were discharged home. The length

Table 1. Demographic, medical, and clinical characteristics of the cohort

	Total number (n = 249)	Low ABCD^2 score (n = 33)	High ABCD^2 score (n = 216)
Demographics			
Age, years	63.9±14.4	58.3±13.5	64.7±14.4
Male	111 (45)	12 (36)	99 (46)
Caucasian	118 (47)	20 (61)	98 (45)
African-American	104 (42)	10 (30)	94 (44)
Hispanic	21 (8)	3 (9)	18 (8)
Asian	6 (2)	0	6 (3)
Medical comorbidities			
Hypertension	183 (73)	21 (63)	162 (75)
High cholesterol	125 (50)	13 (39)	112 (52)
Atrial fibrillation	21 (9)	1 (3)	20 (9)
CAD	57 (23)	8 (24)	49 (23)
Current smoker	58 (23)	7 (21)	51 (24)
Prior TIA	38 (15)	5 (15)	33 (15)
Prior stroke	54 (22)	8 (24)	46 (21)
Diabetes	71 (29)	4 (12)	67 (31)
Hospitalization characteristics			
Initial systolic BP in the ED, mm Hg	146±29	134±37	147±27
Initial diastolic BP in the ED, mm Hg	79±17	75±18	79±16
Motor symptoms	145 (58)	3 (9)	142 (66)
Speech disturbances	128 (51)	9 (27)	119 (55)
Duration of episode	(n = 208)	(n = 28)	(n = 180)
<10 min	35 (17)	14 (50)	21 (12)
10– 59 min	72 (35)	8 (29)	64 (36)
>59 min, <24 h	101 (49)	6 (21)	95 (53)
Single episode at presentation	212 (85)	28 (85)	184 (85)
DWI MRI	(n = 211)	(n = 27)	(n = 184)
Abnormal	61 (29)	5 (19)	56 (30)
Length of stay, days			
Mean ± SD	2.6±3.2	2.7±3.6	2.6±3.1
Median (IQR)	2 (2)	2 (2)	2 (2)
Discharge disposition			
Home or left AMA	233 (94)	31 (94)	202 (94)
Inpatient rehabilitation	11 (4)	2 (6)	9 (4)
Long-term acute care	3 (1)	0	3 (1)
Transfer to another hospital	1	0	1
Expired	1	0	1
Symptomatic carotid stenosis >50%	15 (6)	2 (6)	13 (6)

Data are given as n (%) or mean ± SD, unless otherwise indicated. CAD = Coronary artery disease; BP = blood pressure; IQR = interquartile range; AMA = against medical advice.

of time between symptom onset and presentation to the ED was <12 h for 146 patients (59%), <24 h for 45 patients (18%), <48 h for 18 patients (7%), and >48 h (n = 15, 6%) or unknown (n = 30, 12%) for the remaining patients. The majority of patients had hypertension (73%) and hyperlipidemia (50%). Mean systolic and diastolic blood pressure at presentation was 145 and 79 mm Hg, respectively. The median ABCD^2 score was 4; 216 patients (86.7%) were considered high-risk (scores ≥3). Symptomatic carotid stenosis >50% was present in 16 patients (8%, out of 201 available studies). Table 1 summarizes patient demographics and

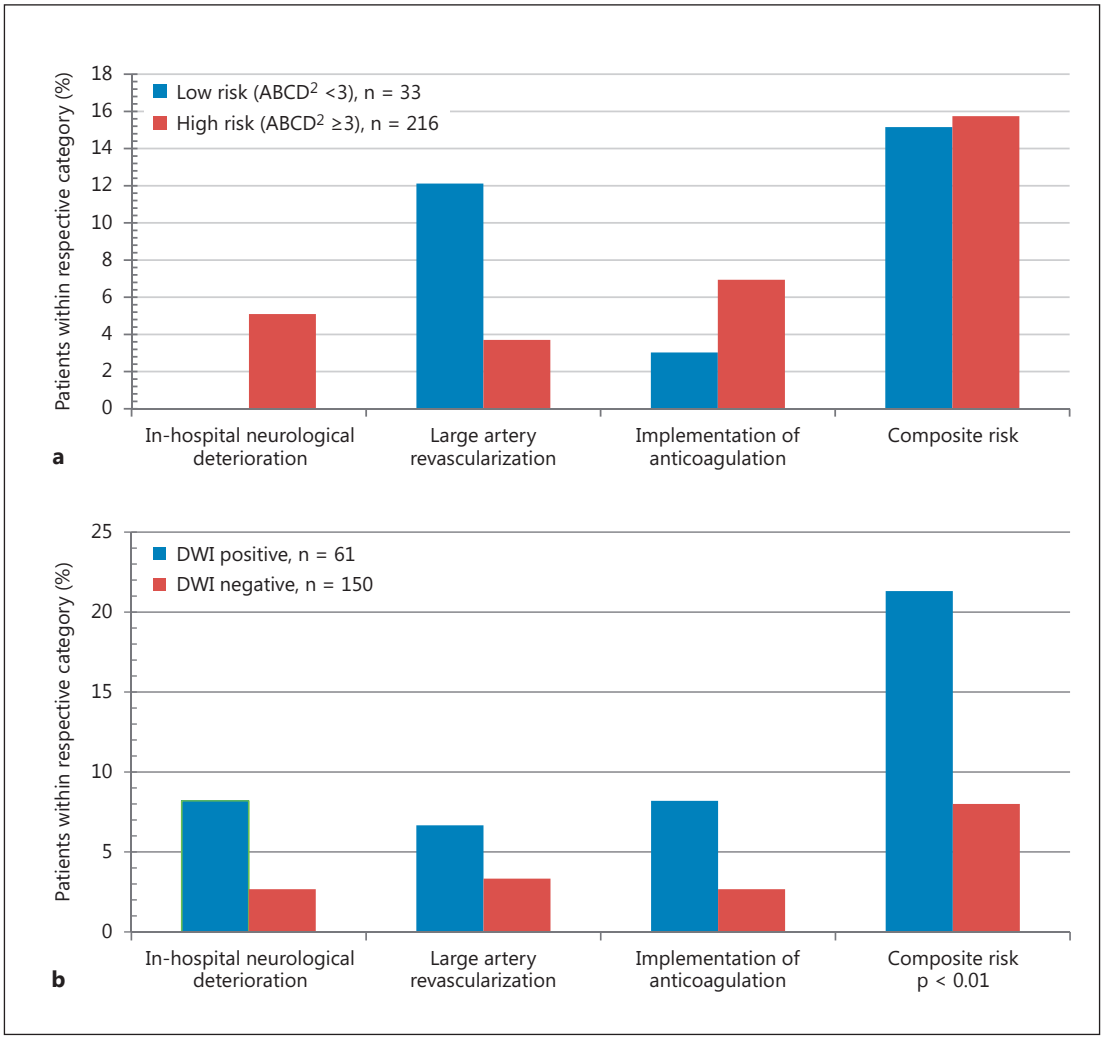

Fig. 1. a Findings dichotomized by ABCD^2 category. **b** Findings dichotomized by DWI status.

clinical characteristics overall and between groups. The ABCD^2 score, in-hospital ischemic events, and in-hospital intervention data were available for all patients.

Eleven patients had in-hospital ischemic events: 8 TIAs and 3 ischemic strokes. All patients with recurrent events had ABCD^2 scores ≥3, while none of the patients with lower scores had in-hospital ischemic events during their stay (5.1 vs. 0%, p = 0.37; fig. 1a). All 11 patients with in-hospital ischemic events had hospital stays >48 h, and all of the events occurred after the initial 48 h. No patient with recurrent symptoms received intravenous or endovascular reperfusion therapy due to contraindications (recent stroke, low NIHSS score at time of deterioration) or elapsed time window. Two of the 3 ischemic strokes were cryptogenic, while the third was cardioembolic in a patient with a persistently subtherapeutic international normalized ratio and decompensation due to a congestive heart failure exacerbation. On review, no clear change in management could have prevented the first two events. None of the patients with an in-hospital ischemic event had >50% carotid stenosis, although 4 patients had ipsilateral intracranial atherosclerosis.

A total of 12 patients (4.8%) underwent inpatient revascularization for large artery stenosis (3 intracranial, 9 extracranial); none were in the group with recurrent ischemic events while hospitalized. The median time to surgery was 3 days after symptom onset. Nine of the 12 patients (75%) had stenosis that was >70%. There was no difference in the rate of revascularization among patients with low versus high ABCD^2 scores (9.1 vs. 4.2%, p = 0.20; fig. 1a). Anticoagulation was initiated in 16 patients (6.4%) and was similar by ABCD^2 score groups (p = 0.59). Two patients were started on anticoagulation for arrhythmias seen while in the ED, 1 for atrial fibrillation seen on Holter monitoring, and 5 based on the results of echocardiograms. When combining recurrent ischemic events, revascularization, and initiation of anticoagulation, the ABCD^2 score did not predict the composite risk (the high ABCD^2 score was 20.4%, versus the low ABCD^2 score of 21.2%; p = 0.91).

Two hundred and 11 patients (85%) underwent an MRI, of whom 61 had at least 1 DWI lesion present that correlated to their symptoms. ABCD^2 score groups were not associated with DWI findings; 30% of patients with ABCD^2 scores ≥3 had DWI lesions compared to 19% of those with low ABCD^2 scores (p = 0.26). A positive finding on DWI was not correlated with the likelihood of in-hospital deterioration (p = 0.31), anticoagulation (p = 0.12), or the need for revascularization (p = 0.13); however, it was associated with an increased risk of the composite of revascularization, recurrent TIA or stroke, or initiation of anticoagulation (p < 0.01; fig. 1b).

Discussion

In our study, nearly one-fifth of presumed low-risk TIA patients (ABCD^2 <3) underwent in-hospital large artery revascularization or initiation of anticoagulation. While only those with ABCD^2 scores ≥3 had in-hospital recurrent ischemic events, justifying the current recommendation for hospitalization, our findings suggest that patients with ABCD^2 scores <3 may harbor high-risk stroke conditions that require urgent in-hospital management. This includes arrhythmias that may have previously been undetected.

Although the AHA guidelines support the use of the ABCD^2 score, the score's ability to triage TIA patients for admission is questioned. This topic was of renewed interest as of late, with a meta-analysis showing that the ABCD^2 score does not reliably discriminate between those at low and high risk of early recurrent stroke [14]. Perhaps supplementing this score with the addition of vascular and brain imaging results is preferred, as several studies have noted improved discrimination between different risk groups by doing so [6, 15–19]. Indeed, net reclassification into low- and high-risk groups when including vessel and brain imaging approaches one-third of patients compared to the simpler ABCD^2 score [20]. Symptom fluctuation and prior TIA within 7 days of index TIA, in combination with the ABCD^2 score, may also be valid predictors of early stroke risk [16, 21]. Finally, a new prognostic score has recently been described, which may be more accurate in determining high- and low-risk patients [22]. Whether obtaining expedited testing using rapid MRI and telemetry is a feasible option remains to be seen, as one recent paper found that TIA patients had better outcomes when hospitalized in stroke units compared to elsewhere [23], and another suggested that those patients with minor stroke or TIA who are discharged from the ED are less likely to receive timely stroke care interventions [24]. Of note, expedited evaluation in an outpatient clinic or a clinic with 24-hour access may ameliorate this effect [24, 25].

Only 2 prior studies have evaluated the relationship between the ABCD^2 score and in-hospital intervention, observing that patients with a lower score have a similar probability of requiring in-hospital treatment as those with higher scores [12, 13]. Our study expands on these findings by observing that in the 85% of patients who underwent MRI, the presence of

DWI lesions strongly correlated with subsequent recurrent TIA or stroke, in-hospital revascularization, or initiation of anticoagulant therapy. An imaging-based triage strategy may therefore be more useful than the ABCD^2 score for determining composite risks of stroke and the need for in-hospital risk-modifying treatments.

Our study does have several limitations. First, it was conducted at a single urban tertiary care center, which limits the ability to generalize these findings more broadly. Second, our sample size was small, especially with regard to event rates of recurrent events or revascularization. This likely limited the power to detect small but meaningful differences between groups. Third, we did not systematically perform radiographic assessment after in-hospital deterioration, leading to possible diagnostic misclassification of outcome. In addition, index TIA with normal DWI results may have been misdiagnosed (i.e. migraine) despite expert neurovascular evaluation. Fourth, as we focused solely on deterioration during the initial hospital stay, data were not collected at 7, 30, and 90 days. Lastly, based on the small number of patients admitted with low ABCD^2 scores, it is also possible that patients were not recognized as TIA and discharged from the ED without evaluation by the stroke team. Similarly, patients admitted with possible TIA and later given an alternative diagnosis were not captured. This would limit the number of subsequent events captured in that subset of patients. However, the number of patients with ABCD^2 scores <3 in our study is similar to that in other cohort studies, mollifying these concerns [7]. In addition, it is the practice of the neurologists at this institution to admit all patients with TIA, regardless of the ABCD^2 score, limiting the number of patients lost following an index event.

Conclusions

Our findings suggest that all TIA patients should be considered for hospitalization on the basis of a heightened risk of early ischemic events and rapid access to risk-modifying treatments such as revascularization and anticoagulation. Advanced imaging showing restricted diffusion suggests a higher risk for both in-hospital deterioration and a potential need for in-hospital intervention. Triage based on the ABCD^2 score alone may delay revascularization or anticoagulation in nearly 20% of patients.

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Disclosure Statement

All authors declare no potential conflicts of interest.

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