Stroke Risk after Nonstroke Emergency Department Dizziness Presentations: A Population-Based Cohort Study

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Objective: Acute stroke is a serious concern in emergency department (ED) dizziness presentations. Prior studies, however, suggest that stroke is actually an unlikely cause of these presentations. Lacking are data on short- and long-term follow-up from population-based studies to establish stroke risk after presumed nonstroke ED dizziness presentations.

Methods: From May 8, 2011 to May 7, 2012, patients ≥45 years of age presenting to EDs in Nueces County, Texas, with dizziness, vertigo, or imbalance were identified, excluding those with stroke as the initial diagnosis. Stroke events after the ED presentation up to October 2, 2012 were determined using the BASIC (Brain Attack Surveillance in Corpus Christi) study, which uses rigorous surveillance and neurologist validation. Cumulative stroke risk was calculated using Kaplan–Meier estimates.

Results: A total of 1,245 patients were followed for a median of 347 days (interquartile range [IQR] = 230–436 days). Median age was 61.9 years (IQR = 53.8–74.0 years). After the ED visit, 15 patients (1.2%) had a stroke. Stroke risk was 0.48% (95% confidence interval [CI] = 0.22–1.07%) at 2 days, 0.48% (95% CI = 0.22–1.07%) at 7 days, 0.56% (95% CI = 0.27–1.18%) at 30 days, 0.56% (95% CI = 0.27–1.18%) at 90 days, and 1.42% (95% CI = 0.85–2.36%) at 12 months.

Interpretation: Using rigorous case ascertainment and outcome assessment in a population-based design, we found that the risk of stroke after presumed nonstroke ED dizziness presentations is very low, supporting a nonstroke etiology to the overwhelming majority of original events. High-risk subgroups likely exist, however, because most of the 90-day stroke risk occurred within 2 days. Vascular risk stratification was insufficient to identify these cases.

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Dizziness is a common reason that patients present to the emergency department (ED).[1,2] In these presentations, substantial concern exists regarding central nervous system (CNS) causes, particularly ischemic stroke.[3–5] Public service campaigns about stroke urge patients with sudden dizziness to call for an ambulance.[6,7] Further reflecting increasing concern about CNS causes is the substantial rise in the use of head computed tomography (CT) in ED dizziness visits over time.[1,8]

Despite this substantial concern, large cross-sectional studies suggest that the proportion of acute dizziness presentations that are caused by stroke is low (around 3%), and is particularly low (0.7%) in the absence of accompanying CNS signs or symptoms.[1,2,9,10] However, it remains possible that the proportion of dizziness cases with cerebrovascular causes (stroke or transient ischemic attack [TIA]) may be higher than reported previously, because posterior circulation vascular events are

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known to closely mimic a variety of other causes of dizziness, and ischemic causes are usually missed by head CT. If stroke masquerading as a non-CNS disorder is common among acute dizziness presentations, then a high rate of stroke in the follow-up period – perhaps approaching the risk that occurs after a stroke or TIA (4.0–18.5% at 90 days)[11–16] – would be expected.

Prior studies have assessed the risk of stroke in the time period after ED dizziness presentations.[17–19] However, these studies used retrospective designs, administrative databases, and International Classification of Diseases 9th edition (ICD-9) codes for case capture and outcome determination. The aim of the current study was to determine the cumulative risk of stroke after ED dizziness presentations using a cohort analysis nested within prospective, population-based studies of dizziness and stroke that apply several methods for optimal case capture and a validated method for stroke outcome determination.

Patients and Methods

Study Design and Setting

The Dizziness Evaluation and Treatment in Corpus Christi, Texas (DETECT) project is an ED dizziness surveillance study in Nueces County, Texas. Patients presenting to any of the 6 adult care EDs in the county between May 8, 2011 and May 7, 2012 were identified. Corpus Christi makes up >95% of the Nueces County population and is an urban environment on the Texas Gulf Coast. The population of the county is approximately 340,000.[20] It is a nonimmigrant community, with very little migration of individuals.[21] Sixty-one percent of the population is Mexican American, 33% is non-Hispanic White, and 6% is of other racial–ethnic background.[20] A substantial majority (89%) of Nueces county residents who live in a Spanish-speaking household also speak English "very well" or "well."[20] There is no large academic medical center in Corpus Christi. In addition, the community is about 200 miles from Houston and 150 miles from San Antonio, and the surrounding counties are sparsely populated, allowing for complete case capture of acute disease. The study was approved by the institutional review boards of the University of Michigan, the Corpus Christi hospitals, and the Texas Department of State Health Services (TDSHS).

Identification of Dizziness Visits

Adult patients aged ≥45 years presenting to the ED with dizziness symptoms were identified using both active and passive surveillance. Multiple methods of case capture were used to reduce selection bias. For active surveillance, trained research associates screened ED triage logs that were specifically designed for this study. The log contained clinical information regarding the patient's reason for visit (RFV) as documented at initial encounter by ED staff and also the subjective assessment (SA) at the time of triage. RFV is typically a brief statement of chief complaint(s), whereas SA is typically written as a short narrative. Information is entered using free text. Both of these data points were included because prior data assurance steps revealed that the initial RFV information could later be replaced with the diagnosis for admitted patients. The primary screen for active surveillance consisted of review of the RFV and SA sections for any of the following symptoms: dizziness, vertigo, and imbalance. For passive surveillance, 2 methods were used for case capture. First, an automated search of the ED administrative databases for dizziness-specific ICD-9 codes (780.4, 386.XX, 438.85, and 781.2) recorded as principal or additional diagnoses was performed. Second, abstractors for the Brain Attack Surveillance in Corpus Christi (BASIC) project, an ongoing surveillance study in this same community (see methods for BASIC below), searched for documentation of dizziness symptoms in visits meeting the BASIC criteria for stroke.

For all dizziness visits that were identified by active or passive surveillance, the ED physician record was reviewed. Dizziness was classified as a principal reason for the visit when the ED physician record had a dizziness symptom documented as one of the top 3 complaints or a dizziness diagnosis (eg, dizziness not otherwise specified, vertigo not otherwise specified, benign positional vertigo, vestibular neuritis) was made. Exclusion criteria included out-of-county residence, institutionalized persons, dizziness caused by trauma, and dizziness that was not a principal reason for the visit.

For all visits with dizziness as a principal reason for the visit, information on demographics, history of present illness (HPI), past medical history (PMH), first recorded blood pressure, examination findings, diagnostic tests, diagnoses, consultations, and admission status was abstracted from the ED record. If not explicitly documented, HPI, PMH, examination, testing, and consultation items were considered not present or performed. The first recorded diagnosis on the ED physician note was considered the primary diagnosis. Neuroimaging information was abstracted for studies performed in the ED or during a hospitalization that resulted from the ED visit.

Identification of Outcomes

Subsequent strokes among the DETECT subjects were identified through October 2, 2012 by merging the DETECT data with the data from the BASIC project. BASIC is an ongoing stroke surveillance study conducted in Nueces County, Texas, since 2000. The methods of the BASIC project have been published previously.[22] Briefly, cases of potential stroke among patients ≥45 years of age were captured by active and passive surveillance of all 6 hospitals in the county. Cases were ascertained actively by searching admission logs for a set of validated screening terms, and passively via ED and hospital discharge records using ICD-9 discharge codes for stroke (codes 430–438, excluding codes 433.x0 and 434.x0, where x = 1–9, 437.0, 437.2, 437.3, 437.4, 437.5, 437.7, 437.8, and 438). Validation of potential stroke cases was performed by board-certified neurologists who reviewed ED and hospital source documentation and applied international criteria.[23] DETECT and BASIC data were merged using Link Plus, a probabilistic

record linkage program developed at the US Centers for Disease Control and Prevention. Matching variables were first name, middle name, last name, date of birth, medical record number, ZIP code, Social Security number, and gender. Manual review was used to determine match status for all potential matches. The location of the acute infarction was abstracted from the radiology report. The National Institutes of Health Stroke Scale was either recorded from the chart or abstracted using a previously validated approach based on the first documented physician examination.[24]

Deaths during the follow-up period were identified by merging dizziness visits captured in this study with a 2010–2012 Nueces County vital statistics database obtained from TDSHS. The databases were merged with the Link Plus program using the following variables: first name, middle name, last name, date of birth, ZIP code, and gender. Manual review was used to determine match status for all potential matches.

Statistical Analysis

Demographic information, medical history, and stroke risk factors were summarized with percentages or medians and interquartile ranges (IQRs), tabulated by stroke status during follow-up. Time to stroke in days was calculated by subtracting the DETECT presentation date from the date of the BASIC stroke presentation, with cases censored at death or on October 2, 2012, whichever came first. Cumulative risk for stroke after dizziness presentation was determined using the Kaplan–Meier product limit estimates. Excluded from the Kaplan–Meier analysis were cases validated as stroke for their index dizziness presentation, using ED and hospitalization records (if relevant), as our aim was to determine stroke risk among patients with a nonstroke dizziness event. In individuals with multiple dizziness presentations, only the first visit was used.

To explore whether clinical risk stratification may help identify patients at high risk of stroke, patients were categorized into levels of cerebrovascular risk using 2 separate schemes: the $ABCD^2$ score and the Framingham Heart Study (FHS) stroke risk score.[25,26] Both schemes had to be modified in this study based on available data. The modified $ABCD^2$ score was calculated for each subject by assigning points as follows: age 60 years or older = 1, systolic blood pressure $\geq$ 140 or diastolic blood pressure $\geq$ 90 = 1, symptoms or examination findings of unilateral weakness = 2, speech disturbance without weakness = 1, and history of diabetes = 1.[25] The original $ABCD^2$ score also assigned 0–2 points based on the duration of symptoms. Because symptom duration was not readily available from chart abstraction, we assigned each patient 2 points as has been done previously.[27] The modified $ABCD^2$ score was reported categorized as 0–3 (low), 4–5 (intermediate), or 6–7 (high).[25]

The FHS risk score algorithm was used to classify patients into long-term risk categories.[26] FHS is calculated by adding values assigned to the following risk factors, which vary based on gender: age, systolic blood pressure (varying based on treatment status), diabetes, current smoking, cardiovascular disease (history of myocardial infarction, angina pectoris, coronary insufficiency, intermittent claudication, or congestive heart failure), atrial fibrillation, and left ventricular hypertrophy (LVH) on electrocardiogram. We were not able to include a score for LVH, because electrocardiograms were not collected. Patients in the current study were assumed to have treated blood pressure when a history of hypertension was documented. The cardiovascular disease variable was modified, because we did not collect information on angina pectoris or intermittent claudication. The FHS stroke risk score was derived in a stroke-free cohort, so a prior history of stroke variable was not included. To account for a prior history of stroke in our population, we counted a past history of stroke as a component of the cardiovascular disease variable. Long-term cerebrovascular risk was then divided into categories of low (<10%), intermediate (10–20%), and high risk (>20%), as used previously,[28] based on their estimated 10-year risk of stroke using the FHS algorithms.[26] For these scales, HPI and PMH items were considered not present unless explicitly documented as present. The scheme scores were not calculated for patients with missing data.

All analyses were performed using Stata v12.0 (StataCorp, College Station, TX).

Results

There were 5,004 dizziness visits identified between May 7, 2011 and May 6, 2012. Active surveillance captured 3,623 (72.4%) visits, and passive surveillance captured 2,709 (54.1%) (1,328 of the visits were captured by both methods). Excluded were 1,958 visits due to age (ie, age < 45 years) and 223 that were not eligible (ie, primary residence out of county, trauma, or institutionalized). An additional 1,465 visits were excluded because dizziness was not a principal symptom on the physician form (n = 1,351), the patient left before being seen (n = 77), or the records were missing or not available (n = 37). Thus, the final number of dizziness visits was 1,358, representing 1,273 unique individuals (85 repeat visits).

Of these 1,273 first-captured dizziness cases, a validated stroke was the cause of the index presentation in 28 (2.2%; 95% confidence interval [CI] = 1.5–3.2%), of which 25 were ischemic and 3 were intracerebral hemorrhage (ICH). These 28 patients were excluded from subsequent analysis.

Characteristics of the final cohort of 1,245 patients with an index nonstroke dizziness event are presented in Table 1. Median age of the cohort was 61.8 years (IQR = 53.8–73.9), and 61.0% were female. A head CT was performed in 50.8% and magnetic resonance imaging in 2.6%. Consultation with a neurologist was documented in 1.3% (n = 16). A dizziness or vertigo symptom diagnosis was recorded in 80.8% (n = 1,006) of the visits, and was the first listed diagnosis in 66.7% (n = 830). A peripheral vestibular diagnosis was recorded in 7.9% (n = 98) of the visits, and was the first listed diagnosis in 1.5% (n = 19).

TABLE 1. Patient Demographic and Clinical Characteristics from the Time of the Emergency Department Presentation for Dizziness, by Subsequent Stroke Status

Characteristic	No Stroke during Follow-up, No. (%) unless Otherwise Specified, n = 1,230	Stroke during Follow-up, No. (%) unless Otherwise Specified, n = 15
Age, median yr [IQR]	61.8 (53.7–73.7)	72.4 (59.3–83.7)
Female	750 (61.0%)	9 (60.0%)
Ethnicity		
Mexican American	644 (52.4%)	7 (46.7%)
Non-Hispanic white	505 (41.1%)	8 (53.3%)
Other	81 (6.6%)	0 (0%)
Systolic blood pressure, median mmHg [IQR][a]	147 [130–163]	148 [143–160]
Hypertension	728 (59.2%)	8 (53.3%)
Diabetes	343 (27.9%)	7 (46.7%)
Cardiovascular disease[b]	171 (13.9%)	5 (33.3%)
Current smoker	232 (18.9%)	0 (0%)
Prior stroke	85 (6.9%)	6 (40.0%)
Atrial fibrillation	45 (3.7%)	1 (6.7%)
Modified ABCD^2 score risk categories[c]		
Low risk	588 (47.8%)	3 (20.0%)
Intermediate risk	595 (48.4%)	11 (73.3%)
High risk	11 (0.9%)	1 (6.7%)
Long-term cerebrovascular risk categories[d]		
Low risk	634 (53.1%)	3 (20.0%)
Intermediate risk	311 (26.1%)	8 (53.3%)
High risk	248 (20.8%)	4 (26.7%)
Symptoms		
Dizziness, any	1,165 (94.7%)	15 (100%)
Vertigo, any	513 (41.7%)	8 (53.3%)
Imbalance, any	289 (23.5%)	7 (46.7%)
>1	613 (49.8%)	9 (60.0%)
Neuroimaging studies at index visit		
Head CT	620 (50.4%)	12 (80.0%)
Head MRI	29 (2.4%)	2 (13.3%)
Neurologist consultation	16 (1.3%)	0 (0%)
Number of diagnoses, median [IQR]	2 [2–3]	2 [1–3]
First listed diagnosis		
Dizziness or vertigo	816 (66.3%)	14 (93.3%)
Peripheral vestibular disorder	19 (1.5%)	0 (0%)
Other	395 (32.1%)	1 (6.7%)
Admitted to the hospital	142 (11.5%)	1 (6.7%)

[a]Data missing for 36 visits.
[b]Cardiovascular disease considered any of myocardial infarction, coronary artery disease, and congestive heart failure.
[c]Category not determined in 36 patients due to missing data.
[d]Category not determined in 37 patients due to missing data.
CT = computed tomography; IQR = interquartile range; MRI = magnetic resonance imaging.

TABLE 2. Cumulative Risk of Validated Stroke Event after Dizziness Presentation to the Emergency Department, N = 1,245

Days	Cumulative Risk of Validated Stroke Event (95% CI)
2	0.48% (0.22–1.07%)
7	0.48% (0.22–1.07%)
30	0.56% (0.27–1.18%)
90	0.56% (0.27–1.18%)
180	0.73% (0.38–1.41%)
365	1.42% (0.85–2.37%)

CI = confidence interval.

The median follow-up period was 347 days (IQR = 231–436 days). Of these 1,245 presumed nonstroke dizziness patients, 15 patients (1.2%; 95% CI = 0.7–2.0%) had a stroke identified during the follow-up period (15 ischemic stroke, 0 ICH). Median time to stroke was 142 days (IQR = 2–234, range = 1–338 days). Six of the 15 patients had the stroke event ≤2 days from the time of the index dizziness presentation. Stroke risk after dizziness presentation was 0.48% at 2 days, 0.48% at 7 days, 0.56% at 30 days, 0.56% at 90 days, 0.73% at 6 months, and 1.42% at 12 months (Table 2; Fig). A majority (86%) of the 90-day risk occurred within 2 days. The overall incidence rate of stroke in the follow-up period was 13.2 per 1,000 person-years (95% CI = 7.9–21.9).

Stroke location based on imaging reports and other clinical details are presented in Table 3. Cerebellar, brainstem, and thalamic infarction location each occurred in 1 patient.

Cerebrovascular risk categorization is reported in Table 1 and more specifically detailed for patients who had a subsequent stroke in Table 3. Stroke frequency in the low-risk categories was approximately 0.5% (3 of 637 for the modified ABCD^2 score, and 3 of 591 for the long-term score). Of the 6 patients who had a stroke within 2 days, all were classified as intermediate risk by the modified ABCD^2 score. Overall, only 1 of the 15 strokes was classified as high risk by the modified ABCD^2 score and only 4 of the 15 by the long-term score.

Discussion

This study found that stroke risk is low after an ED visit for dizziness that was presumed to be nonstroke in origin. Although prior studies have estimated a low proportion of stroke diagnosis at the time of a dizziness presentation,[1,2,9,10] the subsequent risk of stroke in the remaining patients has not been previously assessed using a cohort design with data collected from prospective, population-based surveillance studies and validated stroke classification methods. The very low subsequent risk of stroke in this study substantiates the prior cross-sectional studies that suggested a low prevalence of acute stroke as the cause of ED presentations of dizziness.

In addition to the population-based design, there were other advantages of this study compared with prior studies on this topic. First, we used multiple case capture methods. We searched for dizziness symptoms documented at 2 points early in the presentation process: the initial encounter and the triage assessment. Visits were also identified by searching administrative databases for dizziness-specific ICD-9 codes listed as principal or additional diagnoses. Furthermore, we reviewed the ED physician record of each captured visit to ensure that dizziness was a principal part of the presentation. Prior studies captured cases only using ICD-9 code databases without additional capture methods or manual review of the encounter.[17–19] Multiple capture methods are necessary, because patients with a primary symptom of dizziness receive a variety of ICD-9 diagnoses,[1] and there is concern that some of these diagnoses (eg, migraine, gastritis, encephalopathy, presyncope) could be misdiagnosed strokes.[4] Another important advantage of our study was the rigorous surveillance for stroke events and the classification of all strokes using validated procedures including neurologist review of the medical records.

Compared with the previous California-based study on this topic,[17] our estimate of stroke risk was somewhat higher (30-day risk of 0.56% compared with approximately

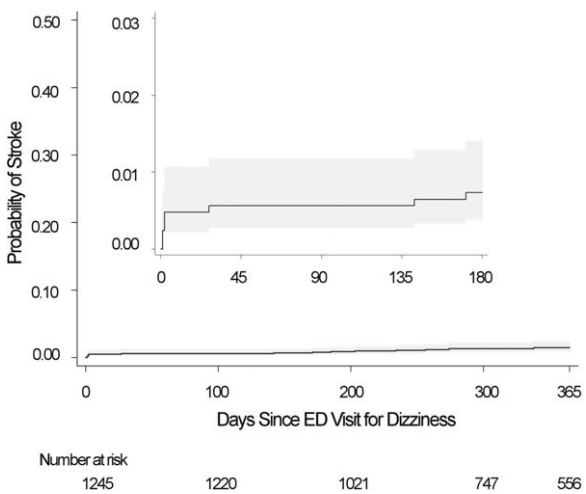

FIGURE Cumulative incidence curve depicting stroke risk after emergency department dizziness presentations. Shaded areas represent 95% confidence intervals. ED = emergency department.

0.30% in Kim et al; 180-day risk of 0.73% vs 0.63% in Kim et al). Conversely, the risk in our study was somewhat lower than that from the Taiwan-based studies (180-day risk of 1.0%).[18,19] The CIs in these studies overlap the point estimates, however, so the differences may be due to chance. A difference in the stroke risk in our population could result from our symptom-based dizziness capture method, our outcome validation method, or the characteristics of our population including patients $\geq$45 years of age and a high proportion of Mexican Americans who are at higher stroke risk than non-Hispanic whites.[29]

An important and consistent finding is that all of the studies reporting stroke risk after dizziness presentations have found that a large proportion of the risk occurs within a short period after the initial presentation. Both the California-based study and the Taiwan-based studies found that this high proportion of the risk in the immediate time period was unique to stroke events because the same finding was not observed with cardiovascular outcomes.[17,19] The Taiwan-based studies also found that this high proportion was unique to dizziness visits because the steep rise in stroke risk was not observed for nondizziness visits.[18,19] This finding suggests that despite the overall low risk, a small subgroup of patients presenting with dizziness presumed to be nonstroke in etiology is likely at high short-term stroke risk. Although the relation of the ED dizziness visit to the stroke cannot be determined with certainty, the large proportion of events that occur within a short time period suggests the possibility that the index event in a small minority of cases was either a stroke or TIA masquerading as another disorder.

Identifying the dizziness patients at high risk is important, but prior studies found that age was the only variable associated with subsequent stroke.[17,19] Combinations of traditional risk factors may stratify the subsequent stroke risk in dizziness patients.[18] We had limited power to formally compare patients with and without stroke to try to identify those at highest risk, although we did explore the utility of using existing cerebrovascular risk classification schemes. In this study, none of the 6 patients who had a stroke within 2 days of the index presentation was in a low-risk category. This information may be useful to identify patients at very low risk of subsequent stroke, although additional validation studies are required. Identification of those at high risk remains a challenge, because about half of the population was categorized as intermediate to high risk by the risk stratification aids. Thus, our study corroborates prior studies indicating that current risk stratification methods do not adequately identify a high-risk group.[27,30] Therefore, more nuanced approaches, perhaps incorporating more details regarding specific eye movement findings in patients with active symptoms, may be necessary.[30,31] However, these prior studies suggesting that eye movement findings can identify high-risk subjects used neurology specialists to perform or interpret the examination.[30,31] Neurologist consultation is likely to be infrequent in routine care settings, as it was in our community, and therefore this strategy may not be feasible for widespread use. An additional challenge to developing decision support in dizziness presentations is that the number of outcome events is very small, so that future work validating assessment tools will need large sample sizes.

Our study provides detail about the findings in neuroimaging studies that were obtained at the subsequent stroke visits. In dizziness presentations, it is likely that the most feared causes or future events are specifically a basilar artery occlusion or a large cerebellar stroke that could result in herniation. However, we found that only 3 of the 15 subsequent strokes had acute cerebrovascular lesions of the cerebellum, brainstem, or thalamus on imaging studies. Although posterior circulation strokes could be under-recognized, and caution in drawing conclusions is advised based on the low number of strokes in this study, these findings indicate that the subsequent risk of a cerebellar, brainstem, or thalamic stroke is much less than the overall risk of stroke in this population. The risk would therefore be even lower for the subsequent occurrence of a basilar artery occlusion or a large cerebellar stroke resulting in herniation. The findings regarding the relatively lower occurrence of posterior circulation strokes also suggests that either most of the subsequent strokes are not related to the index dizziness presentation or, if they are related, that the dizziness stemmed from anterior circulation ischemia or a separate posterior circulation ischemic event related to the subsequent stroke by mechanism (eg, cardioembolism).

The population in this study had a higher proportion of visits with a dizziness or vertigo symptom diagnosis compared with a prior national sample of ED dizziness visits (80.8% vs 20%), and a slightly higher proportion of visits that received a peripheral vestibular diagnosis (7.9% vs 6.1%).[1] These differences may relate to several factors, including the prior study's limitation on the number of diagnoses abstracted from the medical record, our multiple methods to capture cases using symptoms or ICD-9 codes, and the additional criteria we used to focus the population on patients with principal dizziness. The EDs in the current study also use template documentation systems for the physician report, which could influence the diagnoses recorded.

TABLE 3. Description of Validated Stroke Cases That Occurred in the Time Period following an Emergency Department Dizziness Presentation

Index Dizziness Visit					Subsequent Validated Stroke Visit		
Patient, Age	Blood Pressure	Modified ABCD^2 Category (score)	Long-Term Risk Category	Diagnoses	Time to Stroke, days	Imaging Results[a]	NIHSS Score[b]
1, ≥90 years[c]	160/79	Intermediate (4)	Intermediate	Dizziness/vertigo, dehydration	1	HCT: NAD; MRI: acute infarct right frontal, left parietal	4
2, 85 years	147/65	Intermediate (5)	High	Dizziness	1	HCT: NAD; MRI: acute infarct left frontal	6
3, 62 years	144/87	Intermediate (5)	Intermediate	Dizziness, headache, diabetes mellitus, hyperglycemia	1	HCT: NAD; MRI: acute infarct left cerebellar peduncle	0
4, 74 years	148/75	Intermediate (5)	High	Dizziness, vertigo acute, severe hyperglycemia, dehydration	2	HCT: NAD; MRI: acute to subacute infarct right parietal–occipital	6
5, 59 years	176/108	Intermediate (4)	Intermediate	Dizziness, questionable aneurysm	2	HCT: NAD; MRI: NAD by radiologist; stroke pontomedullary junction by neurologist[d]	2
6, 49 years	209/93	Intermediate (4)	Intermediate	Dizziness, orthostasis, hypertensive urgency	2	HCT: not performed; MRI: acute infarct right temporal, right posterior limb internal capsule.	2
7, 83 years	148/70	Intermediate (5)	High	Dizziness, generalized weakness, chronic kidney disease, hyperkalemia, accidental overdose on sleep pills	27	HCT: subacute to chronic right frontal infarct; MRI: NAD	11
8, 53 years	154/71	Low (3)	Low	Dizziness, vertigo, hypothyroidism	142	HCT: NAD; MRI: NAD	7
9, 81 years	146/63	High (6)	High	Dizziness	171	HCT: NAD; MRI: acute infarct left MCA distribution	27
10, 74 years	160/87	Intermediate (4)	Intermediate	Vertigo	185	HCT: NAD; MRI: acute infarct left temporal/parietal	1
11, 88 years	142/70	Intermediate (4)	Intermediate	Dizziness/vertigo acute	203	HCT: NAD; MRI: not performed	17
12, 59 years	130/70	Low (2)	Low	Generalized weakness	234	HCT: NAD; MRI: not performed	5
13, 60 years	168/72	Intermediate (4)	Intermediate	Vertigo, hyperglycemia	256	HCT: NAD; MRI: acute infarct left corona radiata	3
14, 72 years	103/43	Low (3)	Low	Dizziness, hypotension	274	HCT: age-indeterminate left thalamus infarct; MRI: not performed	2
15, 59 years	143/75	Intermediate (4)	Intermediate	Vertigo	338	HCT: NAD; MRI: NAD	3

Additional count data for the 6 patients with a stroke event within 2 days of the index presentation: female, 4; diabetes, 5; high cholesterol, 0; Mexican American, 4; hypertension, 2; cardiovascular disease, 1; atrial fibrillation, 0; prior history of stroke, 2.

[a]As determined on final report by radiologist, unless otherwise indicated.

[b]Median (interquartile range) of NIHSS = 4 (2–7).

[c]To protect patient identity, exact ages of persons ≥90 years old are not reported.

[d]Radiologist report stated no acute disease. Treating neurologist reported acute stroke on MRI.

HCT = head computed tomography scan; MRI = magnetic resonance imaging scan of brain; NAD = no acute disease; NIHSS = National Institutes of Health Stroke Scale.

Limitations

The population was limited to patients age 45 years and older. Inclusion of younger adults could have increased the absolute number of subsequent strokes identified but would have likely lowered the cumulative incidence of subsequent stroke because of the lower stroke risk in younger people. It is possible that some dizziness encounters were missed if the symptoms were not conveyed or documented effectively. It is unlikely that a substantial number of dizziness cases were missed due to a language barrier because most (89%) of the Nueces county residents who live in a Spanish-speaking household also speak English "very well" or "well."[20] Because any missed dizziness visits may or may not have been patients who had a subsequent stroke, it is not possible to determine the direction of this ascertainment bias. The stroke classification in this study was based on the application of validated stroke criteria by study investigators who reviewed source documents. It is possible that we missed or misclassified stroke patients, either at the index visit or a subsequent visit, if the medical evaluation, or documentation of the evaluation, was not sufficient to meet the criteria of our study. It is possible that posterior circulation strokes are more likely to be misclassified than anterior circulation strokes.[32] It is also possible that we missed strokes in patients who did not present to a Nueces County ED for medical attention, although prior research suggests very few out-of-hospital strokes occur in this community.[29] The proportion of patients receiving a CT scan at the dizziness visit was high. This factor may have impacted the identification of ICH cases. However, it is unlikely that it impacted overall acute stroke frequency, because CT is an insensitive test for ischemic stroke, the most common stroke type.[33] Based on available data, we needed to modify the $ABCD^2$ and FHS stroke risk scoring schemes, and thus these were no longer considered validated estimators of actual risk. The cerebrovascular risk scoring methods did not include information regarding current use of antiplatelet or anticoagulant medications. Case selection may have been overly inclusive, resulting in lower stroke risk estimates. Cases were not excluded from the main analysis for any diagnoses other than acute stroke for the following reasons: the validity of other diagnoses was uncertain, other common diagnoses do not preclude a patient from also having a stroke, and posterior circulation stroke is known to masquerade as a variety of other disorders.[4,34]

Conclusions

The risk of stroke after acute presentations for presumed nonstroke dizziness is low. The low risk supports a nonstroke etiology for the original dizziness event in the overwhelming majority of cases. However, high-risk subgroups exist in this patient population. Efficient and effective clinical tools that physicians can use to estimate the risk of stroke in individual patients presenting with dizziness are needed for accurate bedside stroke risk assessments.

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Potential Conflicts of Interest

Nothing to report.

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