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Pediatric Stroke: Do Clinical Factors Predict Delays in Presentation?

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Abstract

Objective—To determine whether age, clinical presentation, or predisposing conditions are associated with delayed diagnosis of arterial ischemic stroke.

Study design—A retrospective chart review of children admitted to tertiary care medical centers in San Diego County between 1995 and 2000. Inpatient charts were screened by ICD-9 codes for strokes, cerebrovascular anomalies, hemiplegia, and migraine.

Results—Time of presentation for medical evaluation did not differ by age group, clinical presentation, or risk factors. There was no relationship between time of presentation and Glasgow Outcome Score. Only 22% of patients (9/41) with ischemic strokes presented for clinical evaluation within 6 hours after onset of symptoms, and an additional 39% (16/41) presented in the first 24 hours. Children who initially presented with altered mental status were more likely to die than those with other initial presentations (OR 9.24; 95% CI: 2.0 – 42.8), but none of the 17 children who presented with hemiparesis died (P = 0.02).

Conclusion—Time of presentation was not related to the clinical factors studied. Early recognition of stroke in children is an important goal for families and health care providers.

Keywords

arterial ischemic stroke; stroke recognition

Strokes are being recognized more frequently in children, even though they may present with less specific symptoms than adults (e.g., altered mental status). Improved diagnosis and understanding of the pathophysiology underlying strokes in children has generated interest in therapeutic interventions. Targeting interventions for these strokes in children is complicated by the variety of predisposing stroke risk factors that are more diverse than in adults, indicating the need for more specific interventions.^{1, 2}

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In adults, time delays for clinical evaluation continue to be a problem, as exemplified by the finding that only 15% of patients were eligible (based on time factors alone) for administration of tissue plasminogen activator (tPA) in one community-based survey.³ Data on the delay of diagnosis of stroke in children are scarce: one published study documented that only one-third of strokes (most of whom had ischemic, rather than hemorrhagic strokes) presented for medical evaluation within six hours of symptom onset.⁴ Of the patients with ischemic stroke, only 30% had an initial exam within six hours of onset of symptoms, and one-third had an imaging study performed within six hours of onset of symptoms. Given that children's strokes are generally recognized later than those in adults⁵, interventions in the later time window or preventive therapy in targeted populations may be more suitable in children than those used in the immediate postictal period. Conversely, earlier presentations give healthcare providers more flexibility and time to determine optimal management strategies.⁵

There is no information about time delays in presentation as they relate to presenting symptoms or underlying risk factors in children,⁶ although there are recent data demonstrating clinical signs that may be different across various age groups.⁷ We sought to identify whether clinical factors were associated with a delay in diagnosis in a population-based retrospective cohort of children with acute ischemic strokes (AIS).

METHODS

We conducted a retrospective chart review of strokes in children aged 1 month to 15 years. The upper age limit was chosen to compare our epidemiological data with prior studies of childhood stroke.^{8,9} All admissions from 1995 to 2000 to any of the hospitals that provide tertiary pediatric neurological care in San Diego County were included. The county has an Emergency Medical Services (EMS) system that provides coverage throughout the region of interest. EMS initially may have transported children with strokes to other hospitals; however, as confirmed by these hospitals, those with ischemic strokes were transferred for evaluation to one of the institutions we reviewed (although patients with hemorrhagic strokes might not have been transferred). Only cases with a San Diego ZIP code listed as the primary residence were studied in order to generate a population-based sample. San Diego County had a population of 2.8 million people in 1999, of whom 625,000 were children, with large representations of white, black, Hispanic, and Asian ethnic and racial groups.¹⁰ The area is relatively geographically isolated, with Mexico to the south, the Pacific Ocean to the West, and relatively low population density regions to the east and north.

Similar to previous studies,^{8,9} inpatient charts were identified initially by the following ICD-9 codes: 430–438 (cerebrovascular disease), 747.81 (anomalies of the cerebrovascular circulatory system), 342 (hemiplegia and hemiparesis), 346 (migraine). The definition of AIS was similar to that used in previous work^{8,9} and the Classification of Cerebrovascular Diseases III¹¹: the sudden onset of a neurological deficit, localized to the brain, lasting more than 24 hours, and imaging that correlated with clinical findings in an arterial distribution (i.e., all patients had either an MRI or CT scan that correlated with the clinical findings). Intracerebral and subarachnoid hemorrhages had similarly derived definitions, with the involvement of intraparenchymal or subarachnoid blood.⁸ Only first-time strokes were considered in this study. The search identified 864 charts, with 859 available for review. Stroke was either the primary reason for admission or a major complication of the admission (e.g., meningitis complicated by a stroke during the course of the infection). In order to maintain consistency with prior studies of strokes in children and because underlying pathologies may have differed from those seen in the majority of patients studied here, the following conditions were excluded from further consideration: neonatal (first month of life) strokes, intracranial hemorrhage after neurosurgical procedures, “clinical” strokes with negative serial MRIs, transient ischemic attacks, post-traumatic petechial hemorrhages and contusions, and strokes associated with

pregnancy, puerperium, and postpartum periods. Outpatient diagnoses and strokes diagnosed as incidental findings also were excluded because data on time of presentation were not available. Trauma, meningitis, and tumors were included as these diagnoses are not always apparent at the time a stroke has been diagnosed. Charts and, when available, EMS records, were reviewed by one of the authors (A.H., J.S.). For some patients, multiple symptoms were noted, but the predominant symptom was scored as the presenting symptom. A preliminary survey of community hospitals in the region suggested that approximately 10–20% of intracerebral hemorrhages were not cared for in the institutions surveyed here.

Data were collected on a standardized form without identifying markers. Basic demographic data, past medical history, family history, clinical presentation, potential risk factors or inciting events, location and type of infarct, results of imaging (all modalities), laboratory work-up, and basic therapy were noted. Diagnostic studies were obtained at the discretion of the treating physician(s) and included laboratory or radiology studies. Delay in presentation for clinical evaluation was assessed on the basis of time of onset from the history, but could not be clearly established in some cases. For analysis, epochs of time were used to indicate the duration between symptom onset and time of presentation noted in the inpatient record (i.e., < 6 hours, 6–24 hours, and >24 hours), analogous to prior studies.^{12,13,14} Outcomes at discharge, measured using the Glasgow Outcome Score (GOS), were based on notes by physicians, physical therapists, or occupational therapists.¹⁵ The GOS was selected because of its ease of application based on information available in the charts. The GOS is a nonlinear scale describing level of care a patient needs after an event: 1 is death; 2 is persistent vegetative state; 3 is severe disability (conscious but disabled); 4 is moderate disability (disabled but independent); 5 is good recovery. When this scale was applied, the determination of ‘independence’ was adjusted for what would be expected for developmentally appropriate activities of daily living in a child of a given age.

Statistical analysis was conducted using SAS Version 9.1 (Cary, NC, USA). For the bivariate analyses, time delay was redefined as a categorical variable reflecting a time from initial presentation to diagnosis of stroke before or after 6 hours or before or after 24 hours. All comparisons of categorical data were made using a chi squared test or Fisher’s exact test.

The Institutional Review Board at each hospital approved this protocol, including Kaiser Permanente Medical Center (San Diego); Naval Medical Center San Diego; San Diego Children’s Hospital; Scripps Mercy Hospital; and University of California, San Diego Medical Center.

RESULTS

General characteristic of the sample

The general characteristics of our study population are shown in Table I and the Figure (available at www.jpeds.com). After application of the exclusion criteria, of 859 charts available for review, 126 children met all study criteria. Ninety patients had nontraumatic strokes. Of these, 62% (56/90) were ischemic and 32% (29/90) were hemorrhagic. The remainder of strokes (5/90) was mixed, and it was unclear whether the major component of the stroke was due to infarct or hemorrhage. Thirty-six patients had strokes associated with trauma. Nearly all the hemorrhagic strokes occurred in patients with vascular malformations or tumors (Table I).

The overall incidence of AIS in this hospital-based retrospective cohort was 1.5/100,000 children/year; for hemorrhagic stroke it was 0.8/100,000 children/year; for all types of nontraumatic stroke diagnosed in the inpatient setting, it was 2.4/100,000 children/year (mixed strokes were included in the latter calculation).

Delay in time of presentation for medical evaluation in patients with AIS

Forty-one of 56 children with AIS had relevant time data documented in their medical chart. Only 22% of patients (9/41) with ischemic strokes presented for clinical evaluation within 6 hours after onset of symptoms, and an additional 39% (16/41) presented in the first 24 hours. Time delays in clinical presentation could not be ascertained for 13 patients. This occurred for a variety of reasons, especially difficulty in determining stroke onset when circumstances precluded observation for clinical changes. Examples include patients with CHD who might have been sedated or paralyzed after corrective surgeries (n=4) and meningitis or systemic infections (n=3). For the remainder, risk factors were varied or unknown.

With respect to AIS, 24% (10/41) of patients were under the age of 2 years; 39% (16/41) were 2 to 5 years of age; 15% (6/41) were 6 to 10 years of age; and 22% (9/41) were 11–15 years of age. There was no statistical relationship between age and strata of time presentation (categorized as < 6 hours, 6–24 hours, of >24 hours; $P=0.52$). Both sexes were equally likely to present for clinical evaluation by three hours and six hours.

Data for clinical presentations of children with AIS were available for 41 patients and included hemiparesis in 37% (15/41), seizures in 20% (8/41), altered mental status in 17% (7/41), fever in 7% (3/41), headache in 7% (3/41), and other presentations (such as ataxia and language abnormalities) in 5 patients. As shown in Table II, there was no statistical relationship between clinical presentation and presentation within 24 hours. However, all children (3) with headache as their chief complaint presented within 6 – 12 hours of symptom onset.

Risk factors and inciting events of children with AIS data were available for 35 of 41 patients. These included congenital heart disease (CHD; both pre- and post-operative) in 24% (10/41) meningitis in 17% (7/41), sickle cell disease in 7% (3/41), trisomy 21 in 5% (2/41), and other (such as prothrombotic disorders) or unknown conditions in the remainder. The number of patients with trisomy 21 was too small for us to evaluate potential confounders of CHD or coexistent cerebrovascular disease (e.g., Moyamoya) in this population. As shown in Table II, CHD was strongly associated with a presentation after 24 hours. Conversely, all three patients with sickle cell disease presented within 24 hours.

Outcomes at the time of discharge from the hospital in patients with AIS were assessed with the GOS in 53 patients where the information could be abstracted reliably from the chart. Nineteen percent (10/53) of the patients died (GOS=1); 15% (8/53) had no disability (GOS=5) and the remainder had varying degrees of impairment. There was no statistical relationship between GOS and strata of time presentation ($P=0.10$). However, children with an initial presentation of altered mental status were far more likely to die than those with other initial presentations (OR 9.24; 95% CI: 2.0 – 42.8). Conversely, none of the 17 children with AIS that presented with hemiparesis died ($P = 0.02$). There was no difference in time delay between patients with ischemic and hemorrhagic strokes, as shown in Table III.

In terms of presentation within the time limit commonly used for anticoagulation, only 3 patients presented by 3 hours after the onset of symptoms: one presented with fever and two presented with hemiparesis. The underlying etiologies were CHD (n = 1; presented with hemiparesis) and meningitis (n= 2; one each presented with fever and hemiparesis).

DISCUSSION

Age, clinical presentation, underlying risk factors, inciting events, or GOS were not associated with time to presentation among children with AIS, although this population-based study may not have been powered to draw these conclusions. Nevertheless, children with sickle cell disease were more likely to present earlier in contrast to children with CHD who were less

likely to present within 24 hours. This study examined clinical factors as they relate to delay in presentation and diagnosis of stroke in children. Given the unique geographic and demographic attributes of the San Diego County study population this review of pediatric stroke cases from 1995 to 2000 provide a rare window to examine the epidemiology of stroke in the pediatric population.

The lack of correlation between age and strata of delay in time of presentation for clinical evaluation in the current study was similar to a previous US study.⁴ Our findings are similar to prior work examining adults with ischemic and hemorrhagic strokes in Denmark, which showed no relationship between symptoms and delay in time to hospital admission.¹⁶ In a Spanish study of adults with strokes, outcomes (measured with the Barthel index) did not correlate with time to first seeing a physician, similar to the present study.¹⁷

We found no difference between ischemic and hemorrhagic strokes as they related to time of presentation, in contrast to a prior US study in children⁴ and a Taiwanese study showing adults with hemorrhages presented earlier than those with ischemic strokes.¹⁴ The reason for this difference might relate to differences in the ages of populations studied (i.e., children vs. adults), number of patients studied, or timing of local medical service delivery (e.g., EMS care).

We did find a relationship between clinical presentation and outcomes. None of the patients who presented with hemiparesis died in our study; patients who presented with altered mental status were likelier to die than the remainder of the study population. This finding may reflect recognition of certain specific symptoms (e.g., hemiparesis) that prompt more immediate medical attention; in contrast, less specific symptoms, such as altered mental status, may not result in a similarly rapid response. However, one US study of adult strokes showed that more severe symptoms and early hospital presentation were associated with worse outcomes.¹² As we did not have access to the actual imaging studies, we were unable to correlate clinical presentations with factors such as stroke size, which may have been an important confounder.

Certain underlying disease states also were associated with time to presentation. All children with sickle cell disease presented within 24 hours, and those with CHD were more likely to present after 24 hours. We speculate that findings in children with sickle cell disease may be related to educational efforts in this population. In the CHD group, sedation or paralysis may have been confounders that limited the ability to make a diagnosis based on clinical criteria. This population merits special consideration for future studies both in terms of risks for and identification of AIS.

The relative isolation of the San Diego area, its diverse population, the multicenter nature of our study, and the concentration of sophisticated medical services provide a relatively unique study sample when compared with prior studies of pediatric stroke. When matched with other published US studies of inpatient diagnosis of pediatric stroke, we found a similar incidence, percentage of strokes that were ischemic or hemorrhagic, and in-hospital mortality. The incidence of strokes ranges from 1.29/100,000 children/year to 2.52/100,000 children/year in US studies of similar age groups.^{8,9,18,19} Earlier population-based studies focused on relatively homogeneous ethnic and racial groups^{8,9,18} or nonurban populations.²⁰ Finally, the use of chart reviews for each patient in this study provides a level of depth that was not achieved by some prior studies. Publications over the past decade have highlighted the importance of adding chart reviews to ICD-9 code searches in both adult and pediatric stroke populations.^{21,22} This may explain some variation from previous studies, because they were either using methodology that did not include thorough chart reviews¹⁹ or were based on more restrictive samples, such as patients enrolled in a managed care plan.²³

Many of the children in our series presented with stroke symptoms different than those typically seen in adults (e.g., neglect, visual field cuts). In the adult age group, women with strokes may

present differently than men, with the former showing more nontraditional stroke symptoms, pain, and change in level of consciousness.²⁴ We did not find any differences between sexes with respect to presenting clinical signs or underlying disease states. These findings suggest that public education regarding strokes in children should include those most commonly seen in the pediatric age group (particularly altered mental status and seizures).²⁵

Due to the study design, we likely have underreported the incidence of stroke during this time period in San Diego and we have not fully characterized patient outcomes. As noted for other studies by the Paul Coverdell National Acute Stroke Registry Prototype Investigators,²⁶ some instances of stroke probably were not included in this study due to missing data and standardization in estimating time of symptom onset in patients with stroke. Secondly, this study only examined inpatient admissions. Consequently, strokes diagnosed in the outpatient setting or diagnosed incidentally were excluded, lowering the estimate of overall incidence. The number of patients included in this study only yielded a power of comparison of ischemic and hemorrhagic strokes of 51%, suggesting that some findings might be more evident in a larger study. Finally, Glasgow Outcome Score, used because it could be applied easily to this data set, could not be reassigned after discharge; consequently, our data do not reflect patient progress over the entire recovery period. Hence, actual recovery over extended periods of time may have been underestimated. Future studies, particularly prospectively ones, may take into account several of these shortcomings including the severity of symptoms, social and caregiver factors, access to health services, and prehospital factors. Larger studies would have a greater power to detect differences between different subgroups, as well.

In conclusion, time delay in presentation for clinical evaluation was not related to age, nor was presenting clinical symptoms, risk factors, or stroke subtype, although this study may have been somewhat underpowered to see these differences. The suggestion that children with sickle cell disease present before 24 hours implies that this group might have benefited from stroke awareness. The findings of delayed presentation in children with CHD and a higher mortality rate in those presenting with altered mental status indicates there are patients in whom increased vigilance may be warranted. Awareness of stroke, particularly recognition of stroke as a complication could be improved in children with conditions that already have brought them to medical attention (e.g., meningitis). For those in whom early detection is difficult (e.g., children with CHD who are sedated or paralyzed), prophylactic therapies or other means of detecting strokes (e.g., imaging) could be used to limit damage from the ischemic insult.²⁷

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List of abbreviations

AIS	arterial ischemic stroke
EMS	Emergency Medical Services
GOS	Glasgow Outcome Score
CHD	

congenital heart disease

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Figure.
Flow diagram of charts reviewed.

Table 1

Characteristics of children admitted for stroke to San-Diego tertiary care facilities between 1995 and 2000.

Characteristic	All Cases (N = 126) number (column %)	Excluding Trauma (N = 90) number (column %)
Mean age in years (SD)	6.7 (4.8)	6.9 (4.7)
Sex		
Male	70 (56%)	53 (59%)
Female	55 (44%)	37 (41%)
Race		
White	35 (28%)	25 (28%)
Black	19 (15%)	15 (17%)
Hispanic	37 (29%)	27 (30%)
Asian	11 (9%)	10 (11%)
Other	24 (19%)	13 (14%)
GOS		
1	18 (15%)	16 (19%)
2	2 (2%)	2 (2%)
3	72 (60%)	45 (52%)
4	8 (7%)	5 (6%)
5	21 (17%)	18 (21%)
Stroke type		
Ischemic	60 (48%)	56 (62%)
Intracranial hemorrhage (ICH)	24 (19%)	12 (13%)
Subarachnoid hemorrhage (SAH)	20 (16%)	12 (13%)
ICH/SAH	8 (6%)	3 (3%)
Ischemic/ICH	4 (3%)	2 (2%)
Intraventricular hemorrhage (IVH)	3 (2%)	2 (2%)
Ischemic/SAH	3 (2%)	2 (2%)
SVT (sinus venous thrombosis)	3 (2%)	1 (1%)
ICH/IVH	1 (1%)	-
Presentation		
Altered Mental Status (AMS)	45 (36%)	24 (27%)
Headache	14 (11%)	13 (14%)
Hemiparesis	22 (17%)	21 (23%)
Fever	5 (4%)	5 (6%)
Seizure	20 (16%)	18 (20%)
Trauma	9 (7%)	-
Other	11 (8%)	9 (10%)
Diagnosis		
Congenital Heart Defect (CHD)	17 (13%)	17 (19%)
Meningitis	12 (10%)	12 (13%)
Moyamoya	3 (2%)	3 (3%)
Sickle cell anemia	6 (5%)	6 (7%)
SVT	3 (2%)	3 (3%)

Characteristic	All Cases (N = 126) number (column %)	Excluding Trauma (N = 90) number (column %)
Trauma	36 (29%)	-
Trisomy 21	3 (2%)	3 (3%)
Vascular malformation	15 (12%)	15 (17%)
Other	31 (25%)	31 (34%)

Table 2

Number of pediatric patients with each characteristic presenting to the hospital by 24 hours after the onset of symptoms to tertiary care facilities in San Diego, California between 1995 and 2000.

Variable	Presenting by 24 Hours	P Value
Presentation		
AMS (n = 7)	4 (57%)	0.82
Fever (n = 3)	1 (33%)	0.30
Headache (n = 3)	3 (100%)	0.15
Hemiparesis (n = 15)	8 (53%)	0.45
Seizure (n = 8)	6 (75%)	0.36
Other (n = 5)	3 (60%)	0.89
Diagnosis		
CHD (n = 10)	3 (30%)	0.02
Meningitis (n = 7)	4 (57%)	0.82
Sickle cell (n = 3)	3 (100%)	0.15
Other (n = 19)	14 (74%)	0.12

AMS= Altered mental status

CHD= Congenital heart disease

Table 3

Time of presentation by stroke type.

Stroke Type	Time to Presentation			P Value ^I
	<6h n (%)	6–24h n (%)	>24h n (%)	
Hemorrhagic	8 (40)	8 (40)	4 (20)	0.22
Ischemic	9 (22)	16 (39)	16 (39)	
Mixed Hemorrhagic & Ischemic	-	3 (100)	-	

^I P-value for table excluding the 3 mixed hemorrhagic and ischemic strokes.