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Original Article

Pediatric Stroke Clinical Pathway Improves the Time to Diagnosis in an Emergency Department

Amy M. DeLaroche MBBS [a,*], Lalitha Sivaswamy MD [a], Ahmad Farooqi MPhil [b], Nirupama Kannikeswaran MD [a]

[a] *Division of Emergency Medicine, Department of Pediatrics, Children's Hospital of Michigan, Detroit, Michigan*
[b] *Department of Pediatrics, Children's Research Center of Michigan, School of Medicine, Wayne State University, Detroit, Michigan*

ABSTRACT

BACKGROUND: Identified barriers to the diagnosis of pediatric stroke include delays in provider recognition and definitive neuroimaging (magnetic resonance imaging). Clinical pathways are recommended to address these barriers; yet few studies have evaluated their impact. Our aim is to describe the effect of a pediatric stroke clinical pathway on the diagnosis of stroke in patients presenting with focal neurological dysfunction to a pediatric emergency department. **METHODS:** The pediatric stroke clinical pathway was implemented in our level 1 pediatric emergency department in June 2014 for children aged one month to 18 years. Demographic and clinical data were collected for patients ultimately diagnosed with stroke using the pediatric stroke clinical pathway and compared with data collected on patients diagnosed with stroke before implementation of the pediatric stroke clinical pathway. **RESULTS:** The pediatric stroke clinical pathway was activated for 36 patients. Stroke was diagnosed in 11 patients (33%), of whom 55% were male with a median age 11 ± 7 years. Focal deficits (82%) and headache (55%) were common presenting complaints. There was a significant improvement in the median time to magnetic resonance imaging from arrival to the emergency department (before implementation of the pediatric stroke clinical pathway: 17 hours [interquartile range 6, 22] versus after implementation of the pediatric stroke clinical pathway: four hours [interquartile range 3, 12]; $P = 0.02$). **CONCLUSIONS:** The pediatric stroke clinical pathway improved time to definitive diagnosis and streamlined the care provided to children presenting to the pediatric emergency department with focal neurological dysfunction.

Keywords: pediatric stroke, clinical pathway, diagnosis, magnetic resonance imaging, cerebral infarction

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Introduction

Stroke is an acute neurological insult that has traditionally been viewed as an adult disease. Although comparatively rare in the pediatric population, with an incidence of two to 13 per 100,000 children,[1] stroke is at least as common as brain tumors in children.[2] With up to three quarters of patients being discharged from the acute care setting with neurological deficits, pediatric stroke results in significant morbidity.[3] Consequently, pediatric stroke leads to substantial health care expenses given the cumulative cost of care over a child's lifespan.[4,5] Early intervention is advocated as a means of minimizing the physical and economic burden of this disease,[6] but timely diagnosis is hampered by the nonspecific clinical presentation of pediatric stroke, and delays in both health care provider recognition of stroke and acquisition of timely definitive neuroimaging with magnetic resonance imaging (MRI).[7-11]

To address these challenges, institutional protocols with development of a "stroke team" have been recommended as part of a multipronged approach toward improving the diagnosis of pediatric stroke.[6,12] The "pediatric stroke alert" has recently been described, and this standardized approach to providing evidence-based care has the

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* Communications should be addressed to: Dr. DeLaroche; Division of Emergency Medicine; Department of Pediatrics; Children's Hospital of Michigan; 3901 Beaubien Street; Detroit, MI 48201.
E-mail address: adelaroc@dmc.org

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potential to improve an institution's capabilities to evaluate and manage acute pediatric stroke.[12] However, few studies characterize the success and limitations of a pediatric stroke protocol,[13] and the impact of standardized care pathways on the diagnosis of pediatric stroke is not well known. Thus the aim of this study is to describe our institution's experience in implementing a pediatric stroke clinical pathway (PSCP) and to evaluate the impact of this PSCP on the diagnosis of stroke in a pediatric emergency department (ED).

Methods

This study was conducted at a freestanding children's hospital in Detroit, Michigan with more than 90,000 ED visits and 10,000 hospital admissions annually. Pediatric neurologists are available 24 hours a day, seven days per week for consultation. Two cohorts of children were included in this study: (1) patients who were diagnosed with stroke before implementation of the PSCP (pre-PSCP) and (2) patients diagnosed with stroke and managed after implementation of the PSCP (post-PSCP).

Patients in the pre-PSCP group were identified through a query of the electronic medical record using International Classification of Diseases-9 codes (434.91, 434.11, and 434.01). Children aged one month to 18 years evaluated in the pediatric ED with neurological deficits and admitted to our institution between 2009 and 2013 with a final discharge diagnosis of ischemic stroke (arterial or venous) were included. Patients in the post-PSCP group were those who presented to the pediatric ED with neurological deficits for whom the PSCP was activated and the final diagnosis was ischemic (arterial or venous) or hemorrhagic stroke with radiological confirmation (MRI). Hemorrhagic stroke included venous sinus thrombosis, hemorrhagic transformation of an arterial stroke, and primary nontraumatic intracerebral lobar hemorrhage. There were no patients with spontaneous subarachnoid hemorrhage. Patients were identified through retrospective review of the PSCP pager log. The pager log is accessed monthly by the institution's communication specialist and emailed to the principal investigator.

The PSCP resulted from a multidisciplinary collaboration between hospital administration and the departments of anesthesia, critical care, emergency medicine, hematology, neurology, pharmacy, and radiology. Following literature review, discussion with other institutions with established protocols, and input from participating departments, the PSCP was implemented in June 2014 following hospital wide lectures and small group sessions directed at nurses and physicians at all levels of training. Implementation was evaluated by a core team of physicians with real-time data used for further education and reinforcement as needed.

The PSCP can be activated for patients aged one month to 18 years presenting to the pediatric ED with a positive "stroke screen" within 72 hours of symptom onset. A positive stroke screen for the protocol was defined as one or more of the following: (1) sudden onset of a focal neurological deficit, which may be motor (gait disturbance, hemiparesis, or facial weakness) or nonmotor (visual field impairment or sensory symptoms) in nature; (2) new onset seizure followed or preceded by a persistent focal neurological deficit; or (3) unexplained alteration of mental status in the presence of a risk factor for stroke. Risk factors were itemized on the PSCP for clinician reference and include a history of one of the following: (1) prior stroke, (2) congenital heart disease, (3) sickle cell disease, (4) head trauma in the past week (5) arteriovenous malformation, (6) hypercoaguability, (7) cranial radiation, (8) acute lymphoblastic leukemia receiving L-asparaginase, (9) Down syndrome, (10) moyamoya disease, (11) mitochondrial encephalopathy with lactic acidosis and stroke-like episodes, and (12) varicella or any significant infection of the head or neck in the preceding three months (Appendix 1).

Clinicians activate the PSCP using a single page number to simultaneously alert attending physicians from the departments of anesthesia, critical care, neurology, and radiology to expedite imaging and hospital admission. Trainees are not involved in the PSCP in an effort to streamline clinical care. With activation of the PSCP, a standardized protocol is initiated. For patients with sickle cell disease, early exchange transfusion is initiated followed by MRI. For patients without sickle cell disease, an urgent CT is followed by MRI. Standard guidelines for presedation fasting are generally followed but general anesthesia is administered by the on-call pediatric anesthesiologist irrespective of these guidelines when clinically warranted. All patients undergo diffusion-weighted imaging first with a complete MRI/magnetic resonance angiogram performed immediately after, or within a few hours, at the discretion of the radiologist and neurologist as long as the patient is clinically stable. For both protocols, the goal is to obtain MRI of the brain within 4 hours of patient arrival to the pediatric ED. When MRI was readily available, the pathway allowed for flexibility and omission of the CT. All neuroimaging, when obtained, was immediately interpreted by the attending neuroradiologist, reviewed by the neurologist, and conveyed to the pediatric ED physician.

The protocol delineates requisite laboratory studies, interventions to be performed in the pediatric ED, guidelines for neuroprotective strategies, and nursing care. Patients with confirmed stroke are admitted to the intensive care unit. A summary of the protocol for patients without sickle cell disease is attached in Appendix 1. Tissue-type plaminogen activator is not routinely used at our institution; thus, standard definitive therapy included anticoagulant or antiplatelet therapy at the discretion of the pediatric hematologist and neurologist.

Demographic and clinical data, including presenting signs and symptoms, physical examination findings, imaging results, and hospital length of stay, were abstracted for both the pre- and the post-PSCP groups using a standardized form. This study was approved by the Institutional Review Board of Wayne State University School of Medicine.

Statistical analyses

Categorical variables were reported in numbers (%), normally distributed continuous variables were reported as the mean ± S.D., and non-normally distributed continuous variables as median and interquartile range (IQR). The Pearson chi-squared test was used to analyze the distribution of categorical variable by groups, provided a minimum expected number of at least five in any cell, otherwise Fisher–Irwin test was used for the analysis. Normality for all continuous variables was tested using the Shapiro–Wilk test as sample size was less than 2000. Two group comparisons for normal continuous variables were conducted using the Student *t* test, whereas non-normally distributed continuous variables were compared using the Wilcoxon rank sum test. The Friedman two-way test was used to study time to neuroimaging performed outside business hours. Median control chart was used to study time to MRI and time to CT. Data were analyzed using the statistical package for the social sciences (IBMSPSS version 23; IBM Corporation, Armonk, New York) and Statistical Analysis System (SAS) (version 9.4; SAS Institute Inc, Cary, NC). Significance level was set at 0.05.

Results

Demographics and symptomatology

Stroke was diagnosed in one third of patients (11/36, 31%) for whom the PSCP was activated (Fig 1). Most of these individuals (7 of 11, 64%) had an ischemic stroke, whereas 36% (4 of 11) had a hemorrhagic stroke. There were no significant differences in the age, sex, race, or time of pediatric ED presentation for patients with stroke pre-PSCP and post-PSCP implementation (Table). However, a significantly higher proportion of patients were triaged as higher acuity for immediate physician evaluation after implementation of the PSCP (Table). A higher proportion of patients in the post-PSCP group lacked risk factors for stroke compared with the pre-PSCP group (7 of 11, 64% post-PSCP versus 8/30, 27% pre-PSCP). Focal neurological deficit and headache were the two most common presenting symptoms for patients with stroke in the post-PSCP group (Fig 2).