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Original Article

Cardioembolic Stroke in Children: A Clinical Presentation and Outcome Study

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ABSTRACT

BACKGROUND: Cardiac disease is a common cause of ischemic stroke in children. Limited information is available about its incidence and long-term outcome. **METHODS:** We undertook a retrospective study of children (age 0-17 years) with cardioembolic arterial ischemic stroke, occurring between 1992 and December 2007. Study subjects were observed at the Winnipeg Children's Hospital and identified using multiple databases and disease code searches. **RESULTS:** We identified 84 children with arterial ischemic stroke, 17 (20%) of which were cardioembolic stroke (15 non-neonates; 10 females; mean age 4.6 years). The crude annual incidence rate for cardioembolic stroke was estimated to be 0.39 and mortality rate of 0.046 per 100,000 person-years. Stroke occurred commonly in children <5 years (65%) and during hospitalization (65%). Initial presenting symptoms were focal deficits 12 (71%), altered consciousness 5 (29%), seizures 5 (29%), and headache 3 (18%). The mean stroke severity measured by Pediatric National Institutes of Health Stroke Scale was 14.5 (range 2-40) at presentation and 3.7 (range 0-9) at discharge, with mean acute recovery from stroke presentation to discharge of 9.94 (0-32). At 2 years, poor outcome was evident in 10 (59%) children: 2 or >2 Pediatric Stroke Outcome Measure score in 6 (35%), death in 2 (12%), and recurrent stroke in 2 (12%). Factors associated with poor outcome included headache ($P = 0.048$), high Pediatric National Institutes of Health Stroke Scale at presentation ($r = 0.57$; $P = 0.05$) and discharge ($r = 0.58$; $P = 0.05$), and high Pediatric Stroke Outcome Measure at discharge ($r = 0.77$; $P = 0.0008$). **CONCLUSION:** Our cohort provides hospital-based incidence estimates for children with cardioembolic stroke. Pediatric National Institutes of Health Stroke Scale performed at different time points can be a helpful tool in measuring stroke recovery and needs to be further explored.

Keywords: cerebrovascular disorders, ischemic, cardioembolic stroke subtype, epidemiology

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Introduction

Childhood arterial ischemic stroke (AIS) results from many conditions including cardiac disease or intervention, hematological and metabolic disorders, vasculopathies, infection, and trauma. One common cause is cardiac disease or cardiac procedures, which account for approximately 25-33% of pediatric stroke.[1-7] In a prospective population-based study, congenital cardiac disease was estimated as a risk factor for pediatric stroke in 24% of neonates and 29% of non-neonates.[2] In children, congenital cardiac malformations and acquired cardiac diseases (cardiomyopathies, arrhythmias, and endocarditis) are the predominant cardioembolic stroke etiologies. Most of the pediatric cardioembolic strokes occur in the setting of cardiac instrumentation[3,8,9] with the highest risk in the first year after the cardiac procedure.[4] Cardiac surgery may induce unrecognized silent infarctions,[10] which may indicate that

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cardioembolic stroke in children occurs more frequently than currently estimated.

Although pediatric cardioembolic ischemic stroke etiologies are well known, limited outcome data are available. Permanent moderate-to-severe motor or cognitive disabilities occur in 75-87% of children with stroke, and death occurs in 5-28%.[3,4,8,11] Outcome is largely dependent on the presence of associated conditions.[2,12,13] Poor prognostic indicators of childhood AIS reported in the literature include young age, presentation with an altered consciousness or seizures, cortical infarction, complete middle cerebral artery territory infarction, infarct size and volume, and identification of certain prothrombotic abnormalities.[8,14] Limited information exists about the predictors of outcome and recurrence of AIS in children with differing etiologic diagnosis, such as cardioembolic stroke. In one study, cardioembolic events represented 33% of pediatric AIS, yet 60% of recurrent strokes were cardioembolic in origin, suggesting an increased recurrence risk in the cardioembolic subtype.[1]

Recently the International Pediatric Stroke Study Group published two reports that included children with cardioembolic stroke. Many international sites contributed patients in this study, including Winnipeg, Manitoba, and other Canadian pediatric care centers. The first report, published in 2009, studied outcomes in 661 children with AIS, both in general and in its etiological subtypes.[14] The study reported the presence of arteriopathy, bilateral ischemia, and decreased consciousness at presentation as poor prognostic indicators. Children with cardioembolic stroke ($N = 131$) did not have a statistically significant difference in outcome compared with stroke in general or its etiological subtypes.[14] The second report, published in 2012, studied the clinical characteristics and early outcome data. They found a trend toward worse outcome and high mortality in the cardiac disorders group ($P = 0.078$) compared with children with other causes of stroke.[15] A recent single center study found that 27% of children with cardioembolic stroke have a risk of recurrent stroke up to 10 years after their sentinel stroke.[12] Previously, the same center had examined predictors of poor outcome but only in children that underwent cardiac surgery and had suffered a cardioembolic stroke. The study found that older age, longer duration of cardiopulmonary bypass, length of postoperative hospital stay, and reoperation suggested poor outcome with only reoperation approaching significance in multivariate analysis.[13] We hypothesized that presenting clinical, laboratory, and radiological characteristics may predict the clinical outcome, including recurrence, death, or sensorimotor dysfunction in children with cardioembolic stroke, both with and without cardiac intervention.

Study objectives

We studied Manitoban children with the diagnosis of cardioembolic AIS. The primary aim was to review the clinical characteristics and outcomes and to determine the value of clinical characteristics in predicting outcome. The secondary aim was to determine if the initial stroke severity measured by the Pediatric National Institutes of Health Stroke Scale (PedNIHSS) is predictive of the Pediatric Stroke Outcome Measure (PSOM) after a stroke in children with cardioembolic stroke.

Methods

Study design

A retrospective study of consecutively enrolled children, birth to17 years, with the confirmed diagnosis of cardioembolic AIS, observed at the Children's Hospital, Winnipeg, Manitoba, Canada, from January 1992 to December 2007. The study received Institution's Research Ethics Board approval.

Patient identification

To ensure complete ascertainment, children with both AIS and cardioembolic ischemic stroke subtype were identified by several relevant sources, including the *International Classification of Diseases*, *Tenth Revision*, medical records discharge code searches, neurology clinic database, and the locally maintained Manitoba Pediatric Ischemic Stroke Database at the Children's Hospital, Winnipeg (the only children's hospital in Manitoba responsible for the management of sick children). The diagnosis was validated by the review of hospital records including radiographic reports and films.

Inclusion criteria

We included both neonates (0-28 days) and non-neonates (age, 29 days-17 years), with a confirmed diagnosis of AIS (all subtypes) and the cardioembolic ischemic stroke subtype, and whose initial stroke event occurred between January 1992 and December 2007. AIS was defined by the presence of persistent focal neurological deficit of acute onset and neuroimaging evidence of focal parenchymal infarct(s) conforming to corresponding arterial territory. Neonatal ischemic stroke was defined as AIS diagnosed after birth and on or before the twenty-eighth postnatal day. The cardioembolic ischemic stroke was defined as AIS secondary to a cardiac disorder or intervention.

Exclusion criteria

Patients without clear documentation of the diagnosis of AIS and patients that had presumed perinatal ischemic stroke were excluded. Presumed perinatal ischemic stroke was defined as stroke in infants >28 days of age in whom it is presumed that the stroke occurred between the twentieth week of fetal life through the twenty-eighth postnatal day.

Data collection methods

Both retrospective and prospective standardized data regarding demographics, clinical, and radiological features and outcome were obtained by reviewing patient's medical chart.

Demographic data

Demographic data included age at the time of stroke, sex, and ethnicity.

Clinical data

Clinical data, inclusive of the following:

1. Clinical signs at the time of presentation classified as focal sensorimotor signs, including hemiparesis, monoparesis, quadriparesis, speech, visual, and other focal neurological deficits, seizures, altered consciousness, and headache, and the presence of associated signs including fever, blood pressure abnormalities, dehydration, sepsis, shock, need for resuscitation and assisted ventilation, and so forth.
2. Neurological examination findings at the time of presentation.