Research in Developmental Disabilities 34 (2013) 1011–1017

Contents lists available at SciVerse ScienceDirect

Research in Developmental Disabilities

Neonatal stroke causes poor midline motor behaviors and poor fine and gross motor skills during early infancy

Chao-Ying Chen [a], Warren D. Lo [b], Jill C. Heathcock [a,*]

[a] Division of Physical Therapy, The Ohio State University, 516 Atwell Hall, 453 West Tenth Avenue, Columbus, OH 43210, USA
[b] Nationwide Children's Hospital, 700 Children's Dr., Columbus, OH 43205, USA

ARTICLE INFO

Article history:
Received 7 September 2012
Received in revised form 29 November 2012
Accepted 29 November 2012
Available online 3 January 2013

Keywords:
Toy exploration
Cerebral palsy
Stroke
Brain injury
Assessment
Development
Rehabilitations

ABSTRACT

Upper extremity movements, midline behaviors, fine, and gross motor skills are frequently impaired in hemiparesis and cerebral palsy. We investigated midline toy exploration and fine and gross motor skills in infants at risk for hemiplegic cerebral palsy. Eight infants with neonatal stroke (NS) and thirteen infants with typical development (TD) were assessed from 2 to 7 months of age. The following variables were analyzed: percentage of time in midline and fine and gross motor scores on the Bayley Scales of Infant Development (BSID-III). Infants with neonatal stroke demonstrated poor performance in midline behaviors and fine and gross motor scores on the BSID-III. These results suggest that infants with NS have poor midline behaviors and motor skill development early in infancy.

Neonatal stroke refers to brain ischemia or hemorrhage that occurs several days before or after birth in term or near-term infants (Lynch, 2009). Factors associated with neonatal stroke include maternal disorders, placental disorders, birth asphyxia, blood and metabolic disorders, cardiac disorders, infectious disorders and/or traumatic injuries (Kirton, Shroff, Pontigon, & deVeber, 2010; Nelson & Lynch, 2004). The diagnosis of neonatal stroke is confirmed by neuroimaging results, such as magnetic resonance imaging (MRI) and the incidence varies between one in 1600–5000 births (Estan & Hope, 1997; Laugesaar et al., 2007; Lee et al., 2005; Schulzke, Weber, Luetschg, & Fahnenstich, 2005).

Infants with neonatal stroke are at high risk for motor dysfunction ranging from mild neurological impairment to cerebral palsy (Lynch, 2009; Mercuri et al., 2004). Infarcts are commonly focal so infants with neonatal stroke are at high risk for hemiparesis where the arm is typically more affected than the leg (Damiano et al., 2006). The prevalence of hemiplegic cerebral palsy reaches 87% (Golomb, Garg, Saha, Azzouz, & Williams, 2008) for infants with arterial ischemic stroke.

Early identification of motor impairment can be difficult (Kirton et al., 2010; Laugesaar et al., 2007; Lynch, 2009; Nelson & Lynch, 2004). Some infants with neonatal stroke who develop hemiplegia appear neurologically normal during early infancy. A definitive diagnosis of hemiplegic cerebral palsy may be delayed until 2 or 3 years of age (and subsequently 2 or 3 years after injury) – when significant asymmetries in upper extremity function and motor skill development are obvious. This is in sharp contrast to adults who have a stroke who are identified with hemiparesis days not years after the brain injury. Delayed motor diagnoses in infants with neonatal stroke limit the opportunity to intervene with rehabilitation during a period of

* Corresponding author. Tel.: +1 614 292 2397; fax: +1 614 292 0210.
E-mail addresses: chen.1740@buckeyemail.osu.edu (C.-Y. Chen), Warren.Lo@nationwidechildrens.org (W.D. Lo), Jill.heathcock@osumc.edu (J.C. Heathcock).

0891-4222/$ – see front matter © 2012 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.ridd.2012.11.028

rapid brain growth and plasticity. A better understanding of common motor skill characteristics in infants with neonatal stroke is needed to aid earlier diagnosis.

Before 12 weeks of age, infants have obvious asymmetric tonic neck reflexes (ATNR), which interfere with midline behaviors that require simultaneous flexion and extension of both arms. After 12 weeks of age, increased midline behaviors help infants to sense themselves through the process of touching and being touched simultaneously. The coordination between midline behaviors and visual inputs facilitates more object manipulation and early environment exploration that promotes further neurological development (Sherick, Greenman, & Legg, 1976). A persistent ATNR can suppress motor development in infants with brain injuries (Majnemer, Brownstein, Kadanoff, & Shevell, 1992) and may disrupt midline performance in infants with neonatal stroke.

Poor muscle strength, joint range of motion, spasticity, and dexterity are common impairments of the affected upper extremity in children with hemiparesis (Klingels et al., 2012) that can interfere with the speed, accuracy and smoothness of movement (Chang, Wu, Wu, & Su, 2005; Hung, Charles, & Gordon, 2010; Ricken, Bennett, & Savelsbergh, 2005). Moreover, the coordination between both arms and hands during bimanual tasks are negatively impacted (Greaves, Imms, Dodd, & Krumlinde-Sundholm, 2010; Utley & Steenbergen, 2006). Previous work has indicated that children with hemiplegic cerebral palsy demonstrated more mirror activities in one hand. This means that voluntary movements of one hand are frequently associated with unintended movements of the contralateral hand (Woods & Teuber, 1978), which disrupts bimanual control (Kuhtz-Buschbeck, Sundholm, Eliasson, & Forssberg, 2000). In addition, children with hemiplegic cerebral palsy use sequential instead of simultaneous movement strategies to perform bimanual tasks. For example, one hand will start to move after the other hand finishes the movement with few overlaps (Hung, Charles, & Gordon, 2004). Both mirror activities and sequential movements result in inefficient movement strategies that interfere with bimanual coordination.

Of the upper extremity deficits observed in childhood (and adult) hemiparesis, midline behaviors, which involve bilateral arm movements, are some of the earliest and most important components of upper extremity development in infancy. For example, a lack of midline movements has been linked to future motor and cognitive impairments (Sherick et al., 1976). Despite the importance of midline behaviors, we are unaware of any previous work that has examined midline behaviors in infants with neonatal stroke. It is unknown if infants with neonatal stroke have impairments in midline behaviors, months, if not years, before hemiparesis can be identified. Therefore, the first purpose of this study is to discover whether infants with neonatal stroke spend less time manipulating toys with both hands in a midline position.

The ability to detect aberrant fine and gross motor performance during early infancy is critical in identifying infants who have motor delay and initiating early intervention services. Clinical measurement with standardized scales is the most common way in current practice to evaluate infants' motor development. Previous research has focused on scale measurement to assess outcomes during childhood after neonatal stroke using the Wechsler Intelligence Scales III and IV (WIS), Pediatric Stroke Outcome Measure (PSOM) and Bayley Scales of Infant Development (BSID-II) (Sreenan, Bhargava, & Robertson, 2000; Westmacott, Askalan, MacGregor, Anderson, & Deveber, 2010; Westmacott, MacGregor, Askalan, & deVeber, 2009; Wulfeck, Trauner, & Tallal, 1991). However, it is unknown whether the standardized scales can identify abnormal motor performance in infants with neonatal stroke and distinguish them from normal infants during the first few months after birth. Since 2006 the Bayley Scales of Infant Development III has been available for clinical use, and it is widely used to screen infants' motor development. To our knowledge there are no reports that assess the sensitivity of the BSID-III to identify fine and gross motor deficits in infants with neonatal stroke. Therefore, the second purpose of this study is to discover whether impaired fine and gross motor performance can be detected in infants with neonatal stroke during infancy using the BSID-III.

Our first hypothesis is that infants with neonatal stroke will spend less time touching/grasping toys with both hands when compared with infants with typical development. The second hypothesis is that infants with neonatal stroke will have lower BSID-III raw, scaled, and composite scores than typically developing infants indicating delayed fine, gross, and overall motor development

1. Materials and methods

1.1. Participants

Sixteen healthy full-term infants with typical development (TD) and eight full-term infants with neonatal stroke (NS) participated in this study from 8 weeks to 26 weeks of age. All infants were born with a gestational age equal to or greater than 37 weeks. Demographic data from the two groups are presented in Table 1. Infants did not differ in baseline characteristics, such as gestational age, birth height, and birth weight as measured tested with non-parametric Mann–Whitney *U* tests. There were a higher proportion of boys in the NS group, although the proportion did not reach statistical significance (Table 1). Infants with NS were recruited from the Stroke Clinic at Nationwide Children Hospital and by word of mouth. All infants in the NS group presented with clinical signs of stroke including, seizures, weakness, or obtundation. Neonatal stroke was confirmed by MRI review by a neuroradiologist. Infants who had congenital anomalies, genetic disorders, or global hypoxic-ischemic encephalopathy were excluded.

This study was approved by Nationwide Children Hospital and The Ohio State research institution review boards (IRB), and informed consent was obtained from the infants' parents.