Motor Outcomes in Premature Infants
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Abstract

Motor impairment is frequently associated with prematurity. Many of the early signs of a significant motor deficit in the premature infant will be transient and resolve during the first year of life. However, despite medical advances in the neonatal intensive care unit, the incidence of cerebral palsy is reported at 32% in infants weighing less than 1,500 grams. The developmental progression of the premature infant, including early differences between full-term and preterm infants, that affects motor examination; factors that predispose premature infants to neuromotor deficits; and the long-term implications of premature birth from a motoric perspective, will be addressed.

Introduction

Follow-up assessment of the high-risk infant has evolved in response to the dramatic increase in the survival rates of very low birth weight babies. Despite advances in medical care, infants born prematurely continue to be at high risk of developing motor deficits. Birth weight and gestational age are critical factors in determining developmental outcomes. In general, the shorter the gestational period or the lower the birth weight, the greater the risk status for motor deficits in the premature infant. Very preterm birth (gestation less than 32 weeks) is a strong predictor of later cerebral palsy (CP).[1] It is reported that approximately 10% of the smallest (<1,000 grams) preterm infants will develop CP.[2] A recent study reported a 32% rate of CP in those infants weighing less than 1,500 grams.[3] Infants who demonstrate early motor impairments that resolve may also have subtle motor deficits that persist, which later impact school performance.[4] It is often difficult to determine which infants are more likely to recover from the consequences of prematurity and neonatal intensive care unit (NICU) hospitalization, so specialized follow-up examinations to detect early motor delays are very important in the care of the premature infant after discharge.

Impact of Prematurity on Motor Development

There are certain factors to consider during the assessment and follow-up of premature infants. Most significantly, the development of a preterm infant will follow expectations for their "corrected age," or age adjusted for prematurity, rather than their chronological age.[5] Thus, an infant born at 32 weeks, with a chronological age of 6 months will probably be performing motor skills closer to a 4-month level. Extremely premature infants may not achieve the same developmental level compared with their full-term counterparts until closer to 2 years of age.[6]

Most NICU Follow-Up Clinics will continue to adjust for prematurity to 2 years of chronological age. Even compared with other children of their corrected age, most infants born more than a few weeks prematurely will demonstrate additional developmental differences associated with prematurity. Muscle tone, or the resistance of a muscle to stretch, is generally much lower actively and passively in the preterm infant compared with the full-term infant.[5] In the first few months, the preterm infant demonstrates more extension and difficulty moving against gravity than the predominantly flexed full-term infant. At 40 weeks gestational age, the preterm infant is similar in muscle tone compared with the full-term infant, but generally never achieves the full degree of flexor tonus that is present in the full-term infant. There is a relative predominance of extensor tonus in the preterm infant that is demonstrated by a tendency for neck hyperextension, decreased antigravity movement, and decreased midline movements.
Primitive reflexes, including the Moro and palmar grasp, may either be absent or persist longer than in the full-term infant.[5] In addition, the rate of development in the preterm infant is often less predictable than in the full-term infant, with developmental lags and catch-up periods occurring.[6] An isolated delay or single abnormal sign does not always indicate that a child has a significant problem, because these infants grow and develop at different rates. The preterm infant may also demonstrate a jittery quality to their movement patterns in the early recovery period. These early differences may not always be indicative of an emerging deficit and may resolve, although some are associated with long-term problems and should be closely monitored.[6] Most mild motor abnormalities detected in the first few months will improve and may completely resolve over time.[6]

The length of hospitalization secondary to medical complications and decreased opportunities for movement may in itself interfere with the acquisition of early motor skills. Gross motor delays in head and trunk control may be present in the infant who required lengthy immobilization caused by medical complications or in those infants with compromised respiratory or cardiac status. Medically fragile premature infants will initially demonstrate hypotonia. This initial hypotonia may reflect an infant's poor medical status rather than a neurological deficit. These early delays may resolve as the infants medical condition improves in the first year.

**Neurological Basis of Motor Deficits in Preterm Infants**

Premature infants are highly susceptible to brain injury because of difficulty with blood flow regulation and the disruption of blood flow and/or oxygen delivery to the brain. The preterm infant is born during a critical period of rapid fetal brain growth and maturation. Thus, the preterm brain is much more susceptible to injury than the full-term infant brain. The brain tissue most prone to injury in the preterm infant is the fragile periventricular area. The larger the area of periventricular injury, the greater the impact will be on subsequent motor function.[4]

Periventricular leukomalacia (PVL) is a specific condition referring to cell death of the white matter surrounding the lateral ventricles.[4] PVL is caused by a combination of decreased blood flow to the brain and decreased oxygen in the blood. PVL is strongly correlated with motor impairments, especially impacting the lower extremities.[4]

Intraventricular hemorrhage (IVH), or bleeding into the ventricles, is also highly associated with motor impairment.[4] The incidence of IVH has been reported to range from 15% to 40%, depending on gestational age.[5] The risk of IVH is highest in the immediate perinatal period, with most bleeds occurring in the first 3 to 4 days after birth. The incidence and severity of IVH are related to the degree of prematurity, with the smallest (especially those weighing less than 1,250 grams) and those born at less than 30 weeks' gestation being at highest risk for IVH.[5] The presence of PVL or IVH greatly increases the probability of an infant developing CP.[5]

It is not uncommon for premature infants to develop motor deficits without an apparent brain injury. Even in infants with the diagnosis of IVH or PVL, the degree of impairment, if any, cannot be accurately predicted. Although these children are at a higher risk, even a precise description of injury does not allow a precise prediction regarding recovery or motor outcome.

**Transient Neurological Abnormalities of Preterm Infants**

Another complicating factor in the early assessment of the premature infant is the fluctuation or transient nature of muscle tone. The incidence of transient neurologic abnormalities ranges from 40% to 80% in premature infants.[6] The clinical manifestations of “transient dystonia” increases in frequency as birth weight and gestational age decrease.[7] Components of transient dystonia include either hypotonia, or more typically, increased muscle tone with extensor hypertonus through the trunk and lower extremities and increased flexor tonus through the upper extremities.
Irritability and hypertonia with excessive neck hyperextension may also be present. Decreased alertness, poor state regulation, or hyperexcitability may also be a transient sign. Some degree of physiologic hypertonia is normally present during the first 3 months, making it difficult to differentiate from the early developing spasticity related to a diagnosis of CP.[6]

Continued transient signs in the third to ninth month are the persistence of primitive reflexes, high tone in the lower extremities with poor truncal tone, or a persistence of extensor tonus in the trunk and lower extremities. Even these later signs of motor dysfunction frequently resolve. In approximately 20% of the cases, the abnormalities in tone persist.[6] The persistence of abnormal motor findings during the newborn period indicates the highest probability of continued abnormality at 1 year of age.[6] Those infants without any transient abnormal motor signs have the lowest rate of subsequent abnormality. At early follow-up visits, it is more important to look for a combination of questionable motor findings than to be concerned about a single worrisome sign. As an example, mildly increased shoulder girdle tone with consistent weight bearing and the ability to reach forward may not be indicative of a future problem. At least two-thirds of very low birth weight infants exhibit a variety of transient neuromotor abnormalities, which will gradually resolve with continued development.[8] When motor impairment persists, a diagnosis of cerebral palsy may be considered.

**Diagnosis of Cerebral Palsy (CP)**

CP is a nonprogressive disorder of posture and movement caused by brain damage or defect that is typically diagnosed by 2 to 3 years of age.[9] Cerebral palsy is also defined as a static encephalopathy with a developmental presentation because the signs and symptoms of the brain injury change as the brain continues to grow and develop.[10] CP represents a group of disorders with impairments ranging from mild to very severe. The impairments emerge slowly over time and are often not apparent during the first few months of life. There is typically a latency period between the original brain insult and the earliest clinical signs of CP.

Prematurity is the number one risk factor for CP.[10] Premature infants with CP will demonstrate increasing abnormalities of muscle tone, reflexes, posture, and movement patterns with increasingly delayed motor milestones. These deficits emerge most significantly between 6 and 18 months corrected age.[8]

**Types of CP**

The most common type of CP diagnosed in the premature population is spastic CP. These infants are usually initially hypotonic, with spasticity developing over time. Spasticity is characterized by increased stretch reflexes, resistance to passive movement with a clasp-knife phenomena, ankle clonus, and increased deep tendon reflexes.[9] The major movement blocks that emerge are at the neck and shoulders at 4 months of age and through the hips and pelvis at 9 months of age.

Most premature infants with CP are diagnosed with spastic diplegia.[1] Spastic diplegia involves increased muscle tone that primarily affects the lower extremities, with the upper extremities being less affected. Spastic quadriplegia interferes with the function of both upper extremities and both lower extremities, with spasticity present at all four limbs. Head and trunk control are decreased.

Spastic quadriplegia tends to be evident in the first 6 months of life and is more commonly associated with PVL.[1] Signs of early spastic hemiplegia include decreased spontaneous activity on the affected side, early hand preference, delayed reaching on the affected side, an absent or delayed positive supporting reflex through one leg, and a tendency to only roll to one side.

Athetoid CP, which is characterized by writhing movements, is not typically associated with prematurity.[1] Ataxic CP is relatively rare and is also not typically associated with prematurity.[9] Proximal hypotonia
typically is part of the movement disorder associated with spastic CP, but isolated hypotonia as a predominant motor impairment is very rare.[1]

**NICU Developmental Follow-Up Clinic**

The NICU Developmental Follow-Up Clinic provides close monitoring of infants who are considered "high risk," including infants born prematurely or at very low birth weight. The goals of follow-up are to identify disabilities as early as possible so that intervention and parental education can be initiated as early as possible, to monitor services provided, and to assess further needs of the infant. Assessment by a team of developmental specialists with expertise in evaluation of high-risk infants provides valuable information for early identification of developmental delays or disorders. The core follow-up team at Lutheran General Children's Medical Center, Park Ridge, IL, includes a physiatrist (physician specializing in physical medicine/rehabilitation) or neonatologist, a nurse, an audiologist, an occupational therapist, a speech therapist, and a social worker. Because the differentiation of normal motor development from potential deficits is often difficult, this combination of professional input is very helpful in gaining a more complete picture of the child. For those children with additional special needs, a pediatric neurologist, educational specialist, pulmonologist, nutritionist, and ophthalmologist may also be part of the follow-up visit.

The nurse weighs, measures, takes blood pressure, and reviews the child's medical and developmental history. The audiologist assesses hearing and also performs tympanometry. The speech/language therapist assesses oral motor skills, articulation, language, and communication. The occupational therapist assesses fine motor skills, gross motor skills, muscle tone, and quality of movement patterns. The social worker assists parents in accessing early intervention and community programs and other resources as needed. The physician reviews the medical and developmental history and performs a physical examination. The physician summarizes the follow-up team's impressions and recommendations with the family and will make referrals for additional developmental or medical services if indicated. A written report is sent to the child's primary physician and to the family. Parents are encouraged to share the report with early intervention programs or with the child's school. The clinic visit is an opportunity to provide suggestions to parents to optimize their child's development. It is also an opportunity to provide anticipatory guidance to parents as to what they can expect at subsequent visits.

**Follow-up Visit Schedule**

A clinic visit at about 4 months corrected age is important in the assessment of early motor development. Motor milestones that should be present at 4 months corrected age include visual tracking in a 180° plane, batting and grasp of a rattle, and midline hand activity. Active head righting in lateral and anterior/posterior planes and neck extension in prone with emerging weight shift for rolling prone to supine should also be present. Following the 1992 American Academy of Pediatrics sleep position guidelines for supine positioning for sleep to prevent sudden infant syndrome, there has been a significant increase in the numbers of infants with poor neck extension and intolerance of prone positioning.[11,12] This finding is frequently a result of limited opportunity and experience in prone position, rather than a true motor delay.

Transient patterns of movement that may persist at the 4-month corrected age visit may include mild asymmetry of the head and trunk. Preterm infants demonstrate a preference for head turning to the right spontaneously and in response to stimulation.[13] Infants with a preference may keep their head rotated to the right 70% to 80% of the time in supine.[13] Random extremity movement may be high and slightly jerky or arrhythmic in quality. Mild startling may be present in response to any change in position or outside stimulation such as ringing a bell or presentation of a visual stimulus. Passive movement may be resisted, with slightly limited mobility at end ranges. Head control may be decreased with the infant being unable to maintain a chin tuck with pull to sit or extend the neck past 45° in prone. With ventral suspension, the infant may be flexed with arms, head, and legs below the horizontal plane of the body.
Abnormal findings at the 4-month visit may include persistent asymmetries of movement patterns or obligatory patterns that the infant cannot easily move in and out of. Marked hypertonia with persistent fisting of hands in all positions, or an early consistent preference for one hand, would also be abnormal. Marked hypotonia with full head lag and a complete absence of head righting reactions is also abnormal at this visit. As previously noted, most extremely premature or medically fragile infants will initially be hypotonic, but if the hypotonia does not begin to improve in the first 4 months, an abnormal finding is recorded.

Between NICU discharge and the 4-month visit, a small percentage of infants will develop early spasticity, usually proximally through the shoulders and hips. Infants with spastic quadriplegia that is moderate to severe may be detected as early as 4 months corrected age.[6] Early signs of spastic quadriplegia include marked flexor hypertonia of the upper extremities with pronounced scapular elevation and retraction and increased extensor tonus of the lower extremities.

Persistent fisting of the hands is also present. The infant with emerging cerebral palsy may roll over early in a reflexive log roll rather than the segmental rolling that is typically developing at 4 months corrected age. The infant may be very irritable and have a low sensory threshold. Early referral to appropriate early intervention services is indicated to maximize the infant’s function.

A clinic visit at 8 months corrected age is an appropriate developmental age to confirm the presence of neurologic abnormalities or the presence of CP.[10] Normal motoric findings that would be expected at the 8-month follow-up visit include directed upper extremity reach, transference of objects from one hand to another, and finger prehension for raking a fine object.

At 8 months corrected age, independent sitting with good trunk control, reciprocal crawling on the abdomen, or creeping in quadruped, and the emergence of transitioning in and out of sitting, should be present.

Transient patterns of movement that may persist in the extremely premature infant may include mild hypertonia or hypotonia.[6] Transitioning in and out of sitting may be difficult because of a delay in the development of trunk rotation and trunk strength. Reciprocal crawling may be delayed. Occasionally, abnormalities in movement patterns with normal muscle tone is present at 8 months.

It is very important to determine why the movement pattern is abnormal. If the child has had little opportunity to engage in an activity such as prone play, development may be delayed because of lack of experience rather than a neurological deficit. Infants whose primary means of mobility is an infant walker or infants who spend long periods of the day in an infant exersaucer may also exhibit motor delays. These children often demonstrate delays in crawling and may also demonstrate plantar flexion in standing, decreased ankle dorsiflexion, decreased trunk control, and decreased trunk rotation as a result of the developmentally inappropriate movement experiences provided by the walker or exersaucer.

Abnormal motor findings at the 8-month visit include the exaggeration or persistence of the transient signs noted at the 4-month visit. The failure to long-sit independently, inability to dissociate the legs for side-sitting and transitional positions, and an inability to alternate the legs for reciprocal crawling would indicate spastic diplegia. The infant with spastic diplegia typically commando crawls and stands on tiptoes with stiffness through the lower extremities. A commando crawl is a crawl in which the infant uses the arms to drag the body forward while the stomach remains on the ground. Diaper changing may be difficult because of resistance to hip abduction. Spastic diplegia may not be detectable at the 4-month corrected age visit, but it will be more obvious with progressive motor development at the 8-month corrected age visit.

An inability to consistently transfer objects to one hand or asymmetry in forward parachute (the reflexive protective reaction of extending both arms when moved forward quickly) and sideways protective extension may be indicative of spastic hemiplegia at the 8-month visit. Fisting of one hand is often the first
indicator of spastic hemiplegia. During crawling, the infant with hemiplegia tends to drag one side of the body rather than alternating arms and legs to progress forward.

Most neurologic findings either resolve or become more permanent during the first year of life.[6] By 15 to 18 months, most of the transient neurologic signs associated with prematurity will have resolved.[6] At 18 months corrected age, the child should demonstrate increasing fine motor coordination for refined activities such as block stacking, holding a crayon, and imitating vertical strokes. Independent ambulation with appropriate foot positioning and hip stability should be present. Abnormal findings at this age would include the persistence of any transient findings at the 4- or 8-month visit. Immature grasping patterns and uncontrolled release or strong asymmetry in hand usage is an abnormal finding. Decreased equilibrium reactions, instability in standing, or abnormal foot positioning in standing and walking would also be considered abnormal.

Subtle Impairments Related to Early Neurological Injury

At the 2-, 3-, and 4-year follow-up visits, refinement and higher-level coordination of fine motor, gross motor, and adaptive self care skills should be evident. It is at these later follow-up visits that the more subtle neurological deficits associated with prematurity will become apparent if they are present.[8] Deficits noted at these visits may include poor shoulder stability that will interfere with age appropriate prehension patterns necessary for drawing, writing, and manipulative tasks. Small tremulous involuntary hand movement is often seen. Poor proximal muscle strength will impact higher-level balance skill necessary for running, jumping, and stair climbing. Difficulties with postural control and gross motor coordination may be present.

Deficits in self-care skills including self-feeding and dressing may be present because of inadequate motor planning abilities or decreased body awareness. Motor deficits will become more obvious in the classroom and on the playground.

Even when a major neurological disorder has been ruled out in the premature infant, there are subtle deficits associated with prematurity and early brain injury that may persist.[8] The total impact of prematurity may not be obvious until the preschool years. A recent study of a group of infants born at <29 weeks indicated that 23% of those children with no diagnosed physical impairment required additional special school services at age 4 to 10 years.[14] Sensory processing deficits or hypersensitivity to sensory stimuli such as touch, sound, and movement frequently occurs in addition to a motor impairment.[4] Decreased attention and high levels of activity, difficulty with self regulation of the arousal system, and fine motor and bilateral coordination deficits are frequently identified in the preschool and school age children, greatly impacting functional and academic performance.[4] Specific learning deficits in the visual motor area continue to be noted in research of low birth weight infants.[15] The terms “subtle” or “minor” impairments do not always reflect the degree of impact that the deficit will have on the child’s long-term outcome or the impact the child’s deficit will have on the family. These findings support the continued monitoring and follow-up of preterm infants into the school years to optimize performance.

Summary

It is important to be aware of the possible consequences of premature birth and their association with the development of motor deficits, as well as the transient signs of motor deviation associated with prematurity that may resolve. It is also important not to prejudge the premature infant in terms of capabilities, despite their high-risk status. Determining when to reassure and when to intervene is sometimes very difficult, and often not clear cut, but comes with continued experience with the variations in preterm infant development and an understanding of the transient compensations that may occur as a result.

The main goal of the NICU follow-up program is to identify any delays or deviations in development of the infant associated with their prematurity or neonatal illness and to provide appropriate services to address the needs of the infant as he progresses. Even if a premature infant is doing well, developmental
suggestions can be made that will positively enhance the infant's motor outcome. Each follow-up examination should not only be viewed as an assessment of the infant, but also as an opportunity for intervention for both the parents and the infant. Using the follow-up visit as an educational experience for the parent is an important addition to the motor screening. Early identification and treatment of CP or other motor deficits may stabilize the impairment and reduce the associated disability, as well as help families better support their child's development.

References


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