Early Neuromotor Reflexes in Infancy

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The early diagnosis of cerebral palsy—during the first 6 to 12 months of life—is considered to be unrealistic since the classical infant neurological examination is not felt to be predictive of later motor function. However, coupling neurological findings with developmental ones (neurodevelopmental assessment) will result in a more comprehensive motor examination which is better predictive of a future significant motor handicap. The "developmental" portion of the neurodevelopmental examination no doubt will enhance the meaningfulness of motor delay or deviance in early infancy. If an infant neuromotor examination is shown to be predictive, no doubt pediatricians would pay more attention to this clinical tool and enhance their skills in very early motor development analysis. Knowledge concerning the appearance of motor milestones is of great importance and the pediatrician should be able to perform an evaluation of not only the presence or delay of a milestone but its qualitative aspects as well.

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PRIMITIVE REFLEXES I

As the Figure demonstrates, Primitive reflexes I represents those automated responses that occur during intrauterine life. There are some reflexes such as a "startle-like" response which appear as early as the 5th week of gestation and suppressed by the 10th or 12th week of intrauterine life. Noninvasive radiographic techniques such as sonography are of great value in studying these intrauterine reflexes. This area will receive a great deal of research attention in the next decade. Standardization and validation for predictiveness for this group of intrauterine reflexes might well result in the evolution of an intrauterine reflex profile (IURP) which will identify a "high-risk" embryo early in intrauterine life. Thus, perinatologists might well have a tool which will be predictive.

PRIMITIVE REFLEXES II

The second grouping of these primitive reflexes are
The traditional reflexes include the Moro reflex (MR), asymmetrical tonic neck reflex (ATNR), tonic labyrinthine reflexes (TNR), positive support reflex (PSR), and the Galant reflex (GR). Other excellent ones included for clinical neuromotor assessment are the stepping reaction, crossed adduction, downward parachute, the plantar grasp, the “neck righting” and the lower extremity and upper extremity placing ones.

If any of these reflexes are present to an exaggerated degree or remain for an unusual period of time they might well be indicative of a cerebral insult or injury. Successful attempts to quantitate these primitive reflexes have been made for a number of them and this “primitive reflex profile (PRP)” gives the pediatrician as well as physical and occupational therapists the opportunity to quantify primitive reflexes in a homogenous-like fashion. Attempts also have been made to derive a primitive reflex score which consists of a compilation of graded primitive reflexes which would either predict delay in gross motor function or in a more subtle fashion be indicative of brain insult or injury. The “validation” of a primitive reflex profile is presently being investigated and hopefully an “Apagarlike” PRP score will be obtained that might correlate with the predictiveness of a significant motor milestone delay.

PRIMITIVE REFLEXES III

Primitive reflexes III are basically the postural reactions consisting of “equilibrium” and “righting” responses that appear while primitive reflexes II are being suppressed. Gross motor function (milestones) appear soon after the postural reactions have developed. A grading of these postural reactions would be most valuable in the clinical arena. However, the majority of these responses are more difficult and time consuming to quantify.

Our Kennedy Clinical Research group has heavily focused upon researching a group of primitive reflexes (primitive reflex profile) which are included in the primitive reflex II group. Primitive reflexes were highlighted because these reactions are present and suppressed during the first 6 months of life, the period of life when pediatricians examine infants more frequently.

In addition, these responses are easy to elicit and quantify. Our research group, for the above reasons, has focused upon the standardization of a primitive reflex profile anticipating that its validation for predictiveness could be ascertained and a primitive reflex profile score documented to predict significant motor disability (cerebral palsy) and possibly predict future motor function.

FLEXOR HABITUS

Before discussing examples of the primitive reflexes II and III it is essential that pediatricians fully appreciate the “flexor habitus” neuromotor posture that full-
term infants assume during late intrauterine life and remaining for the first 2 or 3 months of life. This “flexor habitus” posture may well be the manifestation of the tonic labyrinthine flexor reflex; it is as yet unclear as to whether the infant assumes this flexor position “in utero” from this response or from the contour of the uterus. Thus, initially the flexor responses to these primitive reflexes are somewhat stronger than the extensor ones. During the second to third month of life the flexor response significantly lessens. This change in tone from flexion to “less flexion” can well be demonstrated by following tonal changes manifested by the various primitive reflexes. In analyzing this flexor response it appears that the tonic labyrinthine response, flexor, (accentuated with head flexion) significantly diminishes at the second or third month of life. Also at this time, the neonatal positive support represented by the momentary extension of the lower extremities followed by flexion upon hallucal stimulation coincides with the transgression of total change from flexion to a more neutral-like position. Likewise, the stepping reaction (vertical crossed extension reaction) disappears. During the first 2 months of life with the infant in the vertical position, hallucal stimulation produces a crossed extension response (initial flexion followed by adduction and then extension) resulting in a stepping or walking reflex. This reflex is suppressed with diminishing flexor tonal pattern. One notes that the “sitting in air” position evident under 2 months of life also disappears. Thus, the reflex profile evolves from a posture of flexion into a more neutral one at the second month of life. At this time two prominent postural reactions—the Landau and rotative righting reactions—appear and motor function (rolling over) develops. This physiological transition of primitive reflexes II suppression followed by primitive reflexes III appearance should be most fascinating to pediatricians intriguing them to evaluate the evolution of early immature primitive reactions (PRPII) into the more mature ones (PRPIII) during sequential office visits.

**PRIMITIVE REFLEXES II**

**Classical reactions**

**Moro reflex (MR):** The best known primitive reflex; manifested by upper extremity extension followed by abduction, adduction, semiflexion of the elbows, wrists and fingers with a “C” positioning of the thumb and index fingers. It can be elicited by striking the bassinette on either side, holding the supine infant in the palm of the hand and along the forearm with sudden extension of the head and neck, or lifting infant by upper extremities from a well padded tabletop with sudden release eliciting response. It is still open to question as to whether this is a labyrinthine or tonic neck response.

**Asymmetrical tonic neck reflex (ATNR):** Head rotation to either side produces chin/extension and occiput/extension; infant assumes a “fencing” position. It is interesting to note that prior to understanding the neurophysiology of primitive reflexes, professionals felt that this response had a bonding implication equating it with maternal rejection. It is important for clinicians to realize that an ATNR obligatory response—one in which the infant is unable to habituate this response for an inordinate period of time—can produce occiput/hip dislocation or scoliosis after some months to years. Thus, this is a reflex for which orthopedic surgeons may well recommend therapy, ie, calipers, bracing, casting or even surgery. However, preventative measures—keeping the head in a neutral position—will prevent or at least lessen these complications.

**Tonic labyrinthine reflex—supine or prone (TLS, TLP):** Neck extension produces shoulder retraction, secondary flexion of the upper extremities with extension of the lower extremities; neck flexion produces total flexion habitus. This reflex might well produce the “in utero” positioning seen in the fetus and new-
born period. This reflex differs from the postural reaction, the Landau reflex (LR), in which flexion of the head produces a loss of extensor tone with neutral tone appearing. This mature postural response appears with the simultaneous diminishing of the tonic labyrinthine response. In previous years this reflex used to be considered another maternal rejection, for if exaggerated, the infant in the prone position on the mother's lap would appear as wanting to arch out of the mother's lap.

In the clinical arena this reflex is called "opisthotonic" posturing or "decorticate" rigidity. This reflex is seen following head trauma at any age. It is present with Kernicterus, meningitis and other conditions producing cerebral insult or injury. Some textbooks erroneously describe this physiological response as one in which head extension produces extension and internal rotation of the upper extremities. This is incorrect and in the author's opinion represents a pathological reflex similar to "decerebrate" rigidity, not seen in normal growth and development; neither is it noted in the pre-term development of infants with very low birthweights.

Galant reflex (GR): Stroking the paravertebral area from the thoracic to the sacral region produces truncal incurtavure. This reflex is mentioned because in the past it has received significant notoriety, being equated with truncal instability and reportedly suppressed at 2 months of life. However, studies have demonstrated that this reflex remains for a much longer period of time and the interface between an involuntary and voluntary response remains clouded. Clinical experience suggests that this reflex in isolation is not meaningful but may be if coupled with other persisting primitive reflexes.

Positive support reflex (PSR): This is another fascinating reflex for it can be used to demonstrate the stages through which a primitive reflex passes as the infant moves out of flexor habitus. During the flexor phase with the infant suspended by the axillae it is somewhat difficult to elicit the neonatal (immature) positive support which is represented by momentary extension of the lower extremities followed by flexion when the hallucal area is stimulated. As the infant moves out of the flexor habitus the more "mature" response prevails and this is represented by full extension of the lower extremities with support rendered to the body weight. Again, this appears at about the second month when flexor tone significantly diminishes. If hypotonia predominates, the infant will assume the "sitting-in-air" position with absence of the neonatal positive support response. If this position persists past the third month of life "hypotonic" diplegia should be at high suspect. If, however, the infant has passed through the hypotonic phase with spasticity evident, then an exaggerated "mature" positive support will result in which the infant will not only have full extension of the lower extremities but might well "stand on toes" with or without hip and knee flexion, with or without "scissoring." (It is the involvement of the hip adductors which gives rise to the lower extremity scissoring.)

At this point it seems appropriate to point out that all cerebral palsy is of a mixed physiological picture with one type more predominant than another. Thus, the positive support, and for that matter any of the primitive reflexes will be somewhat modified due to the extent of a "mixed" neurodevelopmental picture (mixture of tone and involved muscle groups).

Symmetrical tonic neck reflex (STNR): This is an enigmatic reflex since it is not present at birth but appears at the 20th week of life. While the time of its suppression is not known, clinical experience demonstrates its suppression prior to the onset of crawling since this reflex in which head control still significantly affects lower extremity tone will preclude lower extremity reciprocal movements.

The STNR is frequently referred to as the "cat reflex" for many remember this reflex by recalling a cat who is about to jump upon a chair or drink milk from a bowl. The former is represented by head extension with extension of the upper extremities and flexion of the lower extremities; the latter response, flexion of the neck accompanied by upper extremity flexion and lower extremity extension. This reflex—still considered as a part of the primitive reflex II profile—might well be a postural reaction and belong in primitive reflex III. Since it is incompatible with reciprocal crawling it is believed to be suppressed by 8 months of age.

Plantar grasp (PG): This reflex is suppressed at 9 months of age. Stimulation of the hallucal area produces a plantar flexion grasp. This response is most pronounced in an infant with spastic diplegia when there is a "clawing" reflex of the toes and foot. Because of this response it is essential that the outer border of the foot be stimulated in an attempt to elicit a Babinski sign. Traversing the hallucal area will elicit a flexor plantar response and mask the traditional Babinski sign—extension of the large toe with fanning of the others. The author believes that the traditional Babinski sign in infancy is probably an "avoidance" motor response. Whether called a Babinski sign or an "avoidance" response both indicate undeveloped myelin, and thus their neurophysiological implication remains the same.

Primate Reflexes II: There are many primitive reflexes II that can be used clinically but are not highlighted in the neurodevelopmental literature. Several ones that are favored by the author because they were found to be clinically useful in the early detection of motor deviancy or impairment.

Placing reactions (PR): The lower extremity placing (LEP) reactions which appear during the first day of life can be elicited by having the tibia pressed against the edge of a tabletop resulting in the 3 phase response—flexion/extension/placing of the lower extremity upon the tabletop. Absence of this reflex
within the first week or so of life should make the examiner suspicious of lower extremity motor dysfunction. This is a reflex that will be clinically rewarding to the examiner if elicited during the nursery stay.

**Upper extremity placing (UEP):** In contrast to lower extremity placing, this response does not appear until 3 months of age. It is elicited by having the lateral surface of the forearm (radius) press and move along the edge of the tabletop from elbow to wrist and dorsum of the hand with flexion/extension/placing of the hand on the tabletop. Absence of this response at 3 to 4 months of age will require closer examination for upper extremity involvement may be present. Asymmetrical absence of the placing responses is commonly seen in hemiplegics. In diplegia, lower extremity placing reactions are frequently absent, delayed or deviant in quality.

**Stepping (walking) reflex (SR):** Until 2 months of age stimulation of the hallicular area will produce an involuntary stepping reflex. If this persists past 2 to 3 months the lower extremities must be carefully examined and observed for motor involvement. Placing the head in extension will of course increase or reinforce the stepping gait since it will elicit the tonic labyrinthine response which produces more extensor tone in the lower extremities as previously noted. It should be pointed out that attempts at enhancing the stepping reaction will not have any effect upon later walking. The stimulation or enhancement of a primitive reflex is not related to fostering a later volitional motor activity. All primitive reflexes are protective responses and are involuntarily elicited. Similar positions are assumed in volitional acts and they are not to be equated with primitive reflexes. The champion “shotputter” is certainly not enhancing his asymmetrical tonic neck response.

**Crossed extension reaction (CER):** This response is the same as the stepping reaction but is elicited with the infant in the prone position. A noxious stimulus to the hallicular area of one lower extremity held in full extension produces three motor responses in the contralateral limb—initially flexion with the second phase, adduction, and the third phase full extension as if to push the noxious stimulus away in the ipsilateral limb. This reflex is suppressed by 2 months of age as is the stepping reaction.

**Downward thrust (DT):** This is a reflex which appears at the 3rd month of life, the time at which the infant has moved out of complete flexor tone. Holding the infant by the axillae and thrusting the lower extremities to the floor elicits full extension of the lower extremities. If the infant is in a hypotonic phase this reflex will be absent, and the “sitting-in-air” posture assumed.

While a quantitation of a single primitive reflex may not be of clinical significance, a compilation or constellation of the grading of several reflexes may be of great value. It is anticipated that a more comprehensive quantification of the primitive reflexes, the primitive reflex profile (PRP), may be a most valuable neuromotor screening tool for the early detection of a significant motor deficit. The primitive reflexes II have been highlighted for they have received a great deal of attention in clinical research endeavors as well as being readily available for clinical appraisal by pediatricians. Primitive reflexes no doubt will receive a great deal of scientific scrutiny in the near future and primitive reflex III, when their quantitation is worked out, may well be a more predictive tool than primitive reflex I schemata.

By demonstrating the validity for predictiveness, pediatricians will absorb them into their clinical armamentarium.

**PRIMITIVE REFLEXES III**

**Postural Reactions**

The two most important postural reactions will be described: the Landau reaction (LR) which appears between the second and third month (again, when the flexor habitus is lessening) and the derotative righting response (DRR) which is the furthest of the midline righting responses into axial derotative ones.

The Landau reaction (LR) is basically a series of midline righting reactions extending from the neck to the trunk and lower extremities producing truncal extension along with hip, knee, and ankle extension as well. Landau's original description includes only the vertebral extension.

The derotative righting response is a more mature one, representing the further maturation of the Landau reaction into a series of axial responses. There are two divisions in the derotative righting reactions: head on body (DRHB) and body on body (DRBB) which are commonly referred to as the “segmental roll” (SR) responses. This basic series of axial righting responses represents the prelude of voluntary rolling over which takes place soon thereafter.

**Descriptions**

**Landau reaction (LR):** Voluntary head extension (neck righting) elicits truncal extension as described above. Derotative righting head on body (DRHB) is elicited by rotating the head past 45° which elicits a series of derotative axial responses starting with the shoulders and followed by the body, hips and lower extremities. The derotative righting, body on body

continued on page 226
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continued from page 223

(DRBB), is elicited by crossing the lower extremities and again derotation of the body is elicited with segmental rolling of the lower extremities followed by the hips, trunk and upper extremities. As mentioned above, these reflexes together with the head "righting" reaction and voluntary roll demonstrates the neuroevolution of primitive reflexes into postural reactions soon followed by voluntary movements (motor milestones).

In the newborn period the neck "righting" reaction is most evident, and this is elicited by turning the head 45° with the infant in the prone position producing an involuntary roll in a "log-like" fashion. This, again, occurs while the infant is in the more pronounced physiological flexor habitus. When the flexor position diminishes, the Landau reaction appears, and soon thereafter the derotative righting responses.

DEROTATIVE RIGHTING SYNTHESIS

Close observation of the derotative roll with its "neurodevelopmental" synthesis will give clinicians clues as to whether the upper or lower extremities are more involved. For example, in the derotative righting response—if the lower extremities are significantly involved as in diplegia, and hypertonia is present there will be a derotative righting from the head through the shoulders but a "log-like" roll of the lower extremities with the lower extremities turning in a "mermaid-like" fashion. The derotative righting of the upper extremity denotes normalcy while the nonderotative or "log-like" roll of the lower extremity is indicative of lower extremity spasticity. This observation requires the division of the DRHB and DRBB into two segments (upper and lower extremities) and from a neurodevelopmental viewpoint any infant with the primiti

tive "log-like" response (involving either upper or lower extremities) is at a high risk for motor involvement.

SUMMARY

While motor milestones—the neurodevelopmental functional end point of the transitioning of the immature and mature primitive reflexes into volitional activity—have been highlighted in predicting future motor function, the primitive reflexes represent the earliest neurodevelopmental markers available for study. By pediatricians becoming familiar with their quantitative and qualitative aspects coupled with the time of their appearance and suppression, they will have this neuromotor tool available for the early detection of a significant motor handicap.

Primitive reflexes II have been highlighted since they are available at birth to be clinically evaluated and followed during sequential office visits during the first 6 months of life, the time during which infants are more closely followed at office visits.

Delay or deviancy (nonequential appearance) of motor milestones are preceded by an exaggeration or delayed suppression of the primitive reflexes.

It is anticipated that the study and standardization of an intrauterine primitive reflex profile will eventually lead to the identification of a high-risk fetus. This endeavor will be fostered by the further development and refinement of non-invasive roentgenographic techniques.

REFERENCES


