Neurodevelopmental Assessment in the First Year with Emphasis on Evolution of Tone

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Neurodevelopmental assessment in the first year of life is important for determining presence or absence of brain damage. Assessment of passive tone is essential for planning interventional therapy. One hundred infants with a normal antenatal, natal and perinatal course were prospectively followed up for one year. Social smile had appeared by 6 weeks in all infants, transfer of objects at 6 months, clapping by 9 months and scribbling on paper (imitative or spontaneous) by 12 months. Neonatal reflexes disappeared by 3 months, lateral propping appeared in all infants at 9 months, however parachute reflex appeared in 96.5% of 87 infants tested at 9 months. Measurement of passive tone by popliteal angle and adductor angle was done at 3, 6, 9, 12 months and scarf sign was also evaluated. The mean popliteal angle increased from 100.6 ± 5.4 at 3 months to 136 ± 4.0 at 12 months, whereas the adductor angle increased from 84.8 ± 6.5 to 126.6 ± 5.3 degrees. The fast and the quick component of the dorsiflexion angle showed a difference of less than 10 at all testings. Assessment of active tone in the form of head support at 3 months was present in all the infants, 95% had pull to sit at 6 months and all 100% had pull to stand at 9 months.

Key words: *Neurodevelopment, Normal infant, Passive tone.*

CHANGES in neuromotor function observed during the first year of life are closely related to the maturation of the central nervous system and the presence or absence of brain damage. Hence it is important to detect abnormalities in neurodevelopment as early as possible, so that intervention programmes can be started(1).

Saint-Anne-Dargassies(2) described assessment of tone as an important aspect of neurodevelopmental evaluation. Muscle tone is difficult to define. It is that condition of the muscle determined by physical, chemical and nervous influences, which determine body posture, the range of movements at joints and the feel of the muscle(3). Passive tone indicates extensibility of a muscle. It is observed by a maneuver evaluating the amplitude of a slow movement executed by the observer, with the infant remaining passive. The result is expressed as an angle or in relation to a landmark (scarf sign). The waxing and waning pattern of tone was described by Amiel-Tison based on the work of Dargassies(4). The passive tone increases in a caudocephalic fashion from 28-40 weeks, so that a term infant is born with maximum physiological hypertonia and the muscle tone then decreases in a caudo-cephalic manner in the first year(5). On the other hand, active tone progresses in a cephalo-caudal fashion from birth to 12 months, so that head support comes first at 3 months and standing with support comes at 9 months.

Various influences, genetic, racial, may play a role in determining passive tone. The

values described in Caucasian French infants may not hold true for Indian infants. The main aim of this study was not only to assess neurodevelopment in normal infants, but to evaluate the changing measurements of passive tone in the form of various angles in the first year of life.

Subjects and Methods

One hundred normal infants discharged from the Obstetric ward of a teaching hospital within a six month period, were enrolled in this prospective study. The inclusion criteria were: (*i*) gestational age >37 weeks; (*ii*) birth weight >2500 g; (*iii*) normal antenatal and perinatal course; and (*iv*) normal delivery.

The exclusion criteria were: (*i*) presence of congenital anomalies or (*ii*) neurologic illness during the 12 month followup.

The mothers were informed about the project and their consent was taken. The infants were examined 24 hours after birth. Their weight, length, head circumference was recorded. Clinical examination was done to rule out any obvious congenital anomaly. Cry, suck, activity and primitive reflexes were noted in order to rule out any neurologic damage.

Every effort was made to get a good follow up. The social worker gave dates of scheduled appointments and a letter was sent one week prior to the appointment. If an appointment was missed, a home visit was made to find out the cause of attrition by the social worker. Socio-economic status was determined by the Kuppuswamy Scale(6).

All the infants were seen in the Well Baby Clinic every month. However, formal neurodevelopmental assessment was done at 3, 6, 9, 12 months. At every visit, a detailed anthropometry was recorded. Weight, height, head circumference were plotted on a growth chart to ensure that there was no growth faltering. Nutritional advice and immunization was given. If the infant was ill on the day of testing, the testing was postponed. However, if an infant came 7 days after the predetermined appointment, the testing was not done. A neurodevelopmental screening test developed in our department and validated on 150 normal infants in our Well Baby Clinic was used.

Tools used

A. Neurodevelopmental assessment

(*i*) A red ball for visual fixation and pursuit.

(*ii*) (*a*) A 'pooja bell' to test hearing at 3 months.
(*b*) A piece of paper - crackling of paper at 6 months

(*iii*) A red rattle and red pen to test mouthing, voluntary reach and transfer of objects.

(*iv*) A coloured paper clip to test for pincer grasp.

(*v*) A paper and pen to see for scribbling (imitative or spontaneous) at one year.

B. Evaluation of passive tone

Goniometer: This is a metallic, non-traumatic portable instrument used for measuring angles. It consists of two arms attached with a screw. On one arm, a protractor is fixed, which is calibrated upto 180 degrees.

The infant was assessed in a quiet room, when he or she was not hungry, sleepy, irritable or sick.

Neurodevelopmental assessment: (1) Examination of head; (2) Neurosensory evaluation-visual fixation and pursuit were tested by a red ball. Hearing was tested by a pooja bell at 3 months and crackling of paper at 6 months; (3) primitive reflexes - palmar grasp, automatic walking, Moro and asymmetric tonic neck reflex at 3 months and protective reflexes like

lateral propping and parachute at 9 months; (4) Motor milestones - head support, sitting, crawling, pincer grasp and standing were recorded; (5) Evaluation of tone was done as resting posture, passive tone and active tone. Spontaneous posture was observed by inspecting the child while he lies undisturbed. Passive tone was evaluated by applying certain maneuvers to the infant while he remains passive at rest. These maneuvers must be performed slowly, gently, and just to the point of discomfort. The resistance of an extremity to this manipulation was measured by recording the angle formed at the joint by this movement, using a goniometer (*Fig. 1*). The following angles were measured.

(*i*) *Angle at hip:* Adductor angle.

(*ii*) *Angle at knee:* Popliteal angle.

(*iii*) *Angle at ankle:* Dorsiflexion angle. The angle was measured using a slow and a quick movement. A difference of less than 10 degrees between the slow and quick angle was considered as normal.

The angles were expressed both as mean (SD) and as ranges. These ranges were then compared with those described by Amiel-Tison.

Active tone was studied with the infant moving spontaneously in response to a given stimulus like head support, pull to sit, pull to stand.

One testing with Bayley Scales of Infant Development was done during the follow-up, at 6, 9 or 12 months(7). A mental and motor quotient ≥85 was considered as normal.

Statistical analysis: The data was fed to the computer and analysed using statistical package for social sciences (version 10.0). Mean and standard deviations were determined.

Results

Baseline data: One hundred full term infants were prospectively followed up for a period of one year. There were 56 males and 44 females in this cohort. Seventy two infants weighed between 2500-3000 g and 28 infants weighed more than 3000 g. Seventy three (73%) infants belonged to the middle class, twelve infants were from the higher class and 15 infants belonged to the lower class. Only 35% of the infants lived in nuclear families and 65% lived in joint families.

During the follow up, three infants developed neurologic problems, and were excluded after 6 months. Three families had moved away. Seven babies did not keep their appointments either due to illness or family problems. So at 9 months, only 87 babies and at 12 months, 88 babies were assessed. Eighty five babies came for all the four assessments. Height, weight and head circumference was within ±2 SD on the growth curve in all the babies.

Fig. 1. Measurement of popliteal angle with a Goniometer.

Neurodevelopmental assessment

(*i*) Examination of head was normal in all infants.

(*ii*) Visual fixation and pursuit was present in all infants by 3 months of age.

(*iii*) *Hearing:* All babies were able to turn towards sound at 3 months (100%). At six months, all babies responded to the crackling of paper by turning the head and eyes towards the sound (100%).

(*iv*) *Primitive reflexes:* Automatic walking, palmar grasp, Moro and asymmetric tonic neck reflex had disappeared at 3 months in all infants (100%).

(*v*) *Protective reflexes:* The lateral propping reflex had appeared in all 87 infants at 9 months (100%). The parachute reflex had appeared in 84 of the 87 infants (96.5%), at 9 months.

(*vi*) *Milestones:* All the salient motor and mental milestones and their age of appearance is shown in *Table I.* Social smile had appeared by history at 6 weeks in all the infants.

(*vii*) *Passive tone:* The adductor and popliteal angles were measured with a goniometer (*Fig.1*). The values of these angles at all the four ages, expressed as mean and standard deviation are shown in *Table II*. The difference in the slow and quick dorsiflexion angle was less than 10 in all infants at all four testings. *Table II* shows the adductor, popliteal and dorsi-flexion angles and the scarf sign in the study group. The same angles described as ranges by Amiel-Tison (6) are shown alongside. The angles described by the French group are wide ranges, hence no statistical test could be applied for comparison.

(*viii*) *Active tone:* There was no head lag at 3 months in all 100 infants (100%). Pull to sit was present in 89 out of 95 infants tested at 6 months (95%). Pull to stand was present in all 87 infants at 9 months (100%).

Thirty six infants were assessed at 6 months, thirty five were assessed at 9 months and twenty four were assessed at 12 months

TABLE I–*Age of Appearance of Milestones*

Milestones	Age of testing (months)	Tested in (n)	Appeared in (n)	(%)
Motor				
Partial head control	3	100	100	100.0
Sitting without support	6	95	86	90.5
Crawling	9	87	71	81.6
Pincer grasp	9	87	78	90.0
Standing without support	12	88	84	95.4
Mental				
Social smile	3	100	100	100
Transfer of objects	6	100	100	100
Midline activity like clapping	9	87	78	90
Scribbling (spontaneous or imitative)	12	88	78	88.6

TABLE II–*Measurement of Angles in Infancy*

Angle	3 months Study Group (n = 100) Range * Mean (SD)	Amiel Tison Range Range * Mean (SD)	6 months Study Group (n = 95)	Amiel Tison Range	9 months Study Group (n = 87) Range * Mean (SD)	Amiel-Tison Range	12 months Study Group (n = 88) Range * Mean (SD)	Amiel-Tison Range
Adductor	70 - 94 * 84.8 (6.5)	40-80	90 - 112 * 103.8 (8.0)	70-110	101 - 125 * 114.1 (6.2)	100-140	118 - 142 * 126.6 (5.3)	130-150
Popliteal	90 - 100 * 100.6 (5.4)	80-100	100 - 122 * 115.3 (6.1)	90-120	110 - 132 * 123.0 (5.6)	110-160	120 - 144 * 136.0 (4.0)	150-170
Dorsiflexion	50 - 59 *55.0 (2.7)	60-70	52 - 64 *57.6 (3.3)	60-70	55 - 68 *62.7 (3.4)	60-70	58 - 72 *65.5 (4.6)	60-70
Diff. in rapid & Slow angle	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Scarf sign	Elbow medial to midline	Elbow medial to midline	Elbow at midline	Elbow at midline	Elbow crosses midline (to opposite side)	Elbow crosses midline (to opposite side)	Elbow crosses midline	Elbow crosses midline

Angles expressed in degrees.

by the Bayley Scales of Infant Development. All the infants had a motor and mental quotient >85.

Discussion

The study of normal development has been a subject of great interest for many researchers. In fact, Charles Darwin published a detailed account of the development of one of his ten children, way back in 1877. Any study in neurodevelopment has to be longitudinal in nature and assessment of tone is an integral part of neuromotor examination. Most conventional neurological assessment tests do not emphasize this aspect. Evaluation of tone must not only be quick and easy, but also standardized. Passive tone is assessed more accurately than active tone because it is independent of strength. It is determined by resting posture, angle of flexion, resistance to extension and passive recoil(8).

With improved survival of 'high risk' newborns in the last two decades, more and more follow up clinics are coming up and the Amiel-Tison method of neurologic assessment is gaining popularity for planning interventional therapy as well as for prediction. We(9) found the 3 month assessment by this method to be a good predictor of outcome at 12 months. Nair(10) feels that Amiel-Tison has provided us with a comprehensive system of neurologic evaluation. Several authors have used the Infant Motor Screen for early prediction(11). Singhi, *et al.*(12) reported that they found the Infant Motor Screen to be highly specific for early diagnosis of cerebral palsy. We(13) found the Amiel-Tison neurological test to be more sensitive in detecting abnormal motor development at 3, 6, 9 months compared to the Bayley Scales of Infant Development, but lost its advantage over BSID at 12 months.

Reade(14) measured the popliteal angle in 130 normal infants using a goniometer to demonstrate the decreasing limitation of knee extension in the first 8 months of life, way back in 1984. Katz, *et al.*(15) used the goniometer to measure the popliteal angle in normal children. Kato, *et al.*(16) studied the evolution of the popliteal angle in the first year of life in five different birth weight categories. They concluded that muscle tone of lower extremities was higher in babies, with birth weight less than 2000 g at 4 months (corrected age) and cautioned against jumping to a conclusion of spastic cerebral palsy. The same authors studied the popliteal angle in infants with periventricular leucomalacia and found a high specificity and positive predictive value at 8 and 12 months for outcome(17). A study from Chandigarh(18) found restricted popliteal angle in 64% of high risk infants, who later developed cerebral palsy.

We used the goniometer to measure the angles in order to get a more objective evaluation, since visual measurements are more subjective. We have also expressed the angles as means with standard deviation, so that other centres could compare their results with our values. As far as the dorsiflexion angle is concerned, it is not the actual angle that is important, but the difference between the quick and slow angle is important. Normally, the quick and slow angles are equal. A difference of more than 10 degrees indicates a powerful stretch reflex due to hypertonicity. We have not measured the heel to ear angle as this angle is difficult to elicit and the maneuver is uncomfortable for the infant.

We have also confirmed the appearance of many milestones in normal Maharashtrian infants. Social smile had appeared in all infants by 6 weeks, much earlier than that reported by Illingworth(9). It is not surprising

Key Messages

- It is important to assess passive tone in the first year for early diagnosis of developmental disabilities and for planning early interventional therapy.
- Measurements of passive tone in the form of adductor, popliteal, dorsiflexion angles in normal Maharashtrian infants at 3, 6, 9, 12 months are determined.

as our infants have so much social contact with relatives and grandparents and 65% our babies lived in joint families. Transfer of objects appeared at 6 months, a month earlier than that reported by Illingworth(9).

In a country like India, where a regular monthly follow up is not possible to study the evolution of tone, only a single examination may be available. Hence, we felt that it was necessary to evaluate these angles at various ages in the first year of life in healthy infants, to provide normative data of passive tone.

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