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Neurodevelopmental Outcome of High-risk Neonates at 24 Months of Age to their Amiel-Tison Tone at Term or Within 3 Months of Age

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ABSTRACT

Background: Improved neonatal care in India, especially Kerala, has reduced neonatal mortality and increased the survival of high-risk neonates. Early identification of predictors for developmental delay enables timely intervention to minimize adverse outcomes. Among several cost-effective methods, Amiel-Tison tone assessment at term or within 3 months of age is a valuable tool to detect potential neurodevelopmental delays.

Methods: Neonates with respiratory distress discharged from SNCU/NICU and returning for follow-up within 3 months were enrolled in this prospective analytical study conducted over 6 years from 2017. Amiel-Tison tone assessment was performed at 40 weeks gestation or within 3 months of age. All babies were followed up to their corrected/completed 24 months of age. Exclusion criteria included gestation below 25 weeks or above 42 weeks, visible birth defects, dysmorphic features, syndromic presentations, and genetic disorders.

Results: Out of 375 neonates with respiratory distress (25 to 42 weeks gestation), all were followed up to their corrected/completed 24 months and assessed using Bayley Scales (3rd edition). Normal Amiel-Tison tone was observed in 333 babies, while 42 had abnormal tone at term or within 3 months. Babies with abnormal tone showed significantly lower mean total and domain-specific scores (cognitive, communication, motor, and social-emotional) compared to those with normal tone.

Conclusion: Abnormal Amiel-Tison tone at term or within 3 months in the high-risk neonate is associated with a high chance of developmental delay and cerebral palsy at their corrected/completed 24 months of age.

Key-words: Ameil-Tison tone, Cerebral palsy, Developmental delay, High-risk newborn

INTRODUCTION

High-risk neonates generally have more chance of developmental delay compared to their normal counterparts based on multiple studies. Many insults occur in the high-risk states during antenatal, perinatal & neonatal periods have varying degrees of impact on the neurodevelopmental outcome of these neonates at their corrected/completed 24 months of age [1-4].

The objective of the present study was to determine whether there is any association between Amiel-Tison tone status at term or within 3 months of age and developmental delay of high-risk newborn at their corrected/completed 24 months of age. Amiel-Tison axial active tone, passive axial tone, popliteal angle, dorsiflexion of the ankle, scarf's sign, and adductor angle were used to determine the tone status of high-risk infants at term or within 3 months of age as normal or abnormal. Studies are relatively less related to the

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association of abnormal Amiel-Tison tone in the early neonatal period and developmental delay [5,6].

The risk factors of neonates enrolled in this study included prematurity, respiratory distress syndrome (RDS), meconium aspiration syndrome (MAS), hypoglycaemia, perinatal asphyxia, sepsis, pneumonia, necrotizing enterocolitis (NEC), intraventricular hemorrhage (IVH), low birth weight, intrauterine growth restriction (IUGR), and persistent pulmonary hypertension of the newborn (PPHN). These risk factors may directly or indirectly cause insults to the preterm/term brain leading to structural and functional damage. These brain lesions may lead to tone abnormalities in these high-risk neonates.

Generally, in preterm neonates, there is hypotonia and the posture is more extended compared to term babies, and the tone gradually increases in caudo-cephalic progression starting from the lower limbs upwards till the baby reaches term (40 weeks). Thereafter tone changes towards normal for age, in the reverse direction, cephalo-caudal. The normal pattern of tone progression and change towards normal for age may alter when there are major insults to the brain due to multiple risk factors. So, tone abnormalities observed after term may have significance in predicting moderate and severe developmental delay later. Tone abnormality may be used as one of the criteria to start early psychomotor stimulation interventions in early infancy [5-7].

MATERIALS AND METHODS

Research design- This community-level prospective observational analytic study was conducted in the south of middle Kerala over 6 years from 2017. Those neonates admitted for neonatal respiratory distress in SNCU/NICU and discharged, coming for follow-up within 3 months of age were enrolled for the study. Amiel-Tison tone assessment done at 40 weeks of gestation or within 3 months of age, assessment done using Amiel-Tison axial active and passive tone, popliteal angle, dorsiflexion, and scarf's sign, noted as normal pattern or abnormal. The risk factors related to antenatal, perinatal events and neonatal morbidity states of all infants from history and discharge summary documented.

Methodology- Neurodevelopmental assessment done by Bayley Scales of Infant and Toddler Development edition -3 (BSID-III). Cognitive, communication and motor domains were assessed by the principal investigator. Social-emotional domain was done using the questionnaire English/Malayalam version, with the help of parents [8]. Developmental assessment in all babies was done at their respective corrected/completed 24 months of age. The raw score thus obtained was converted to the age-specific scaled score and then to the corresponding composite score, which was used for statistical analysis and interpretation [8].

Inclusion criteria

- Gestational age more than 24 weeks and up to 42 weeks
- Admitted for neonatal respiratory distress and discharged from SNCU/NICU
- First seen for follow-up within 3 months of delivery

Exclusion criteria

- Those babies who had visible birth defects (VBD), chromosomal and other genetic disorders, and dysmorphic and syndromic features, were excluded.
- Neonates with gestational age less than 25 weeks and more than 42 weeks were also excluded from the study.
- Babies of parents not provide consent were also excluded from the study.
- Babies not brought for follow-up at corrected/ completed 24 months of age

Statistical Analysis- Descriptive statistical methods, including measures of central tendency, standard deviation, coefficient of skewness, and kurtosis, were applied to summarize the data. Inferential statistical techniques were also utilized, wherein a parametric approach was followed. Specifically, the independent Student's t-test was employed to compare means and assess the significance of findings within the study.

Ethical Approval- Approval for the study was obtained by the institutional ethics committee, School of Behavioural Sciences, Mahatma Gandhi University, Kottayam, Kerala, India dated 22-09-2017.

RESULTS

Table 1 shows that Amiel-Tison tone abnormal at term or within 3 months of age group babies have significantly lower total neurodevelopmental status scores at their completed/corrected 24 months of age, compared to

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Amiel-Tison tone normal group babies. Mean values, standard deviations and t-values of total neurodevelopmental scores of babies at corrected/completed 24 months of age, for their Amiel-Tison tone status at term or within 3 months of age.

Table 1: Neurodevelopmental Scores vs. Early Amiel-Tison Tone Status

Amiel tison tone	Number	Total Neurodevelopmental score		t-value	p-value
		Mean	SD		
Normal	333	360.34	33.59	13.52	0.000
Abnormal	42	296.98	2793		

Table 2 shows that Amiel-Tison tone abnormal at term or within 3 months of age group babies have significantly lower cognitive developmental status scores at their completed/corrected 24 months of age, compared to Amiel-Tison tone normal group babies.

Table 2: Cognitive Scores vs. Early Amiel-Tison Tone Status

Amiel tison tone	Number	Cognitive score		t-value	p-value
		Mean	SD		
Normal	333	86.82	8.20	9.4	0.000
Abnormal	42	74.17	8.40		

Table 3 shows that Amiel-Tison tone abnormal at term or within 3 months of age group babies have significantly lower language developmental status scores at their completed/corrected 24 months of age, compared to Amiel-Tison tone normal group babies.

Table 3: Language Scores vs. Early Amiel-Tison Tone Status

Amiel tison tone	Number	Language score		t-value	p-value
		Mean	SD		
Normal	333	94.08	10.08	8.52	0.000
Abnormal	42	80.17	9.14		

Table 4 shows that Amiel-Tison tone abnormal at term or within 3 months of age group babies have significantly lower motor developmental status scores at their completed/corrected 24 months of age, compared to Amiel-Tison tone normal group babies.

Table 4: Motor Scores vs. Early Amiel-Tison Tone Status

Amiel tison tone	Number	Motor score		t-value	p-value
		Mean	SD		
Normal	333	90.74	9.85	13.92	0.000
Abnormal	42	68.36	9.65		

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Table 5 shows that Amiel-Tison tone abnormal at term or within 3 months of age group babies have significantly lower social-emotional developmental status score at their completed/corrected 24 months of age, compared to Amiel-Tison tone normal group babies.

Table 5: Social-Emotional Scores vs. Early Amiel-Tison Tone Status

Amiel tison tone	Number	Social-emotional score		t-value	p-value
		Mean	SD		
Normal	333	88.69	10.51	11.20	0.000
Abnormal	42	74.29	7.45		

DISCUSSION

Many factors like hypoxic-ischemic encephalopathy grading, imaging within 3 months of age, general movements of Prechetl, Amiel-Tison tone within 3 months of age and serial head circumference measurements are being looked at for predicting developmental delay in high-risk infants. The present study specifically considered the value of the Amiel-Tison tone assessment, which is a cost-effective, non-invasive method that can be done at term or within 3 months of age for determining the chance of developmental delay [9].

Amiel-Tison tone assessment was done in 375 infants at term or within 3 months of age and classified as normal or abnormal patterns and were followed up to their corrected/completed 24 months of age. Neurodevelopmental status scores were determined using BSID-III at corrected/completed 24 months of age in both groups. Study shows that the mean neurodevelopmental total and domain-wise (cognitive, language, motor and social-emotional) scores were significantly lower for the Amiel-Tison abnormal group (N=42), compared to the Amiel-Tison normal group (N=333) in their corrected/completed 24 months of age. So Amiel-Tison abnormal pattern at term or within 3 months of age, group babies have high chance of moderate to severe developmental delay at corrected/completed 24 months of age.

Transient or persistent tone abnormalities detected at term or within 3 months of age are valuable if it can predict moderate to severe developmental delay later so that early focussed psychomotor, auditory and visual stimulation interventions, especially motor can be started before the onset of severe irreversible tone abnormalities [9].

Straathof *et al.* [10] in their prospective study of 39 high-risk neonates with abnormal imaging (MRI, brain) found that hypotonia of the neck and trunk observed within 3 months of age was a common tone abnormality of children developing cerebral palsy later. Hypertonia of the upper limbs, followed by lower limbs were other common tone abnormalities noticed in this study.

Chaudhari *et al.* [11] in a prospective cohort observational study 190 high-risk children were followed up to 5 years for their neurodevelopmental outcome. 67 children had transient tone abnormalities during infancy, and 10 children were diagnosed as having cerebral palsy among the tone abnormality group. Tone abnormality below 6 months detected group babies had significantly low Intelligence quotient (IQ), compared to the normal tone group babies.

Simard *et al.* [12] in this prospective study of 147 risk preterm neonates between 29 weeks and less than 37 weeks, neurological assessment was done by Amiel-Tison tone at term and Bayley-2 at corrected 24 months of age. They found that abnormal Amiel-Tison tone in the term cohort had significantly lower mental, psychomotor and behavioural developmental scores compared to the normal Amiel-Tison tone in the term cohort, signifying the prediction value of Amiel-Tison tone at term in developmental delay and cerebral palsy.

Jain *et al.* [13] in their prospective study of follow-up of 114 high-risk neonates, initial combined screening done using Vojta's neurokinesiological examination, Amiel-Tison angles and head holding grades, found high specificity and sensitivity for prediction of developmental delay at 12 months of age.

Many structural lesions of the developing brain associated with abnormal Amiel-Tison tone, developmental delay and cerebral palsy have been

identified through various types of brain imaging. Intraventricular hemorrhage (grade-II, III and IV) is very strongly associated with these clinical outcomes. [14]

Association of hypoxic-ischemic encephalopathy (HIE) stage-II, III, diffuse and cystic periventricular leukomalacia (PVL) and porencephalic cyst, with the abnormal tone, abnormal general movements, developmental delay and cerebral palsy have been documented. [15,16]

CONCLUSIONS

Amiel-Tison tone assessment at term or within 3 months of age in high-risk infants is a cost-effective, non-invasive method in predicting moderate to severe developmental delay at their completed/corrected 24 months of age, but the normal pattern of Amiel-Tison alone will not rule out developmental delay. Amiel-Tison tone test may be used as a cost-effective and non-invasive screening test at term or within 3 months of age for prediction of developmental delay in high-risk infants along with other methods of imaging, general movements pattern within 3 months of age and serial head circumference measurements. Abnormal Amiel-Tison tone may help to start early psychomotor, auditory, and visual stimulation, especially focussed motor, in high-risk infants to reduce the impact of various antenatal, perinatal and neonatal risk factors on their neurodevelopmental outcome at 24 months of age.

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REFERENCES

[1] Agarwal R, Deorari AK, Paul V, Sankar JM, Suchdeva A. Cranial ultrasonography. In: Agarwal R, Deorari AK, Paul V, Sankar JM, Suchdeva A, editors. AIMS Protocols in Neonatology. 2nd ed. New Delhi: Noble Vision; 2019: 537-40.

[2] Jayakumar PR, Sukumaran PS, Anandakesavan TM. High-risk neonates-follow up and early intervention. In: Anandakesavan TM, Francis F, Raj M, editors. Recent Advances in Neonatology. Delhi: Red Flower Publications Pvt Ltd; 2020: 415-39.

[3] Agarwal R, Deorari AK, Paul V, Sankar JM, Suchdeva A. Follow up high-risk neonates. In: Agarwal R, Deorari AK, Paul V, Sankar JM, Suchdeva A, editors. AIMS Protocols in Neonatology. 2nd ed. New Delhi: Noble Vision; 2019: 445-65.

[4] Beligere N. Follow up of high-risk infants. In: Bhat R, Kumar P, Verma I, Vidyasagar D, editors. Practical Neonatology. 2nd ed. New Delhi: Indian J Pediatr., 2022: 831-39.

[5] Barnes F, Graham L, Loganathan P, Nair V. General movement assessment predicts neurodevelopmental outcome in very low birth weight infants at 2 years-a five year observational study. Indian J Pediatr., 2021; 88(1): 28-33. doi: 10.1007/s12098-020-03365-1.

[6] Glass HC, Li Y, Gardner M, Barkovich AJ, et al. Early identification of cerebral palsy using neonatal MRI and general movements assessment in a cohort of high-risk neonates. Pediatr Neurol., 2021; 118: 20-25. doi: 10.1016/j.pediatrneurol.2021. 02.003.

[7] World Health Organization (WHO). WHO recommendations on interventions to improve preterm birth outcomes. In: WHO Recommendations on Interventions to Improve Preterm Outcomes, 2015: 47-50.

[8] Nancy B. Bayley scales of infant and toddler development, third edition (BSID-III). 2006. Pearson Psychocorp, Green Valley Drive, Bloomington. Available from: www.PearsonClinical.com.

[9] Gosselin J, Gahagan S, Amiel-Tison C. The Amiel-Tison neurological assessment at term: conceptual and methodological continuity in the course of follow up. Ment Retard Dev Disabil Res Rev., 2005; 11: 34-51.

[10]Straathof EJM, Harmer EG, Hensens KJ, Bastide-van Gemert SL, Heineman KR, et al. Development of muscle tone impairments in high-risk infants: association with cerebral palsy and cystic periventricular leukomalacia. Eur J Paediatr Neurol., 2022; 37: 12-18.

[11]Chaudhari S, Bhalerao M, Chitali A, Patil B, Pandit A, et al. Transient tone abnormalities in high-risk infants and cognitive outcome at 5 years. Indian Pediatr., 2010; 47: 931-35.

[12]Simard MN, Lambert J, Lachance C, Audibert F, Gosselin J. Prediction of developmental performance in preterm infants at two years of corrected age: contribution of neurological assessment at term age. Early Hum Dev., 2011; 87(12): 799-804.

[13]Jain A, Veerabhadrappa H, Shrikant SW, Kumari N. Better prediction of neurodevelopmental outcome in babies using combined Vojta's neurokinesiological examination, Amiel-Tison angles, and head holding grades. J Nepal Paediatr Soc., 2021; 41(1): 17-22.

[14]Ballabh P. Intraventricular hemorrhage in premature infants. In: Bhat R, Kumar P, Verma I, Vidyasagar D, editors. Practical Neonatology. 2nd ed. New Delhi: Indian J Pediatr., 2022: 628-31.

[15]Anne RH, Soul JS, Thomas N. Perinatal asphyxia and hypoxic ischemic encephalopathy. In: Eric CE, Anne RH, Camilla RM, Ann RS, Naveen J, editors. Cloherty and Stark's Manual of Neonatal Care. 8th ed. South Asia ed. New Delhi: Wolters Kluwer (India) Pvt. Ltd; 2021: 820-40.

[16]Rai A. Approach to cerebral palsy. In: Anjana T, Ashok R, Jaydeep C, Suchit T, Suneel G, Amola P, editors. Textbook of Growth, Development and Behavioural Paediatr., 2024: 164-67.