Scholars Journal of Applied Medical Sciences
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Neurology

Prediction of Cerebral Palsy and Other Motor Developmental Trajectories in High-Risk Neonate Using the Rapid Neurodevelopmental Assessment (RNDA) and Prechtl's Method of Qualitative Assessment of General Movement (GMsA)

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DOI: 10.36347/sjams.2024.v12i04.020 | **Received:** 13.02.2024 | **Accepted:** 19.03.2024 | **Published:** 22.04.2024

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Abstract **Original Research Article**

Background: The integration of the RNDA and Prechtl's Method offers a promising approach to identify high-risk neonates and predict their motor developmental trajectories. This early identification can guide clinicians in providing timely interventions, improving the long-term outcomes and quality of life for infants affected by CP and other motor disorders. ***Objective:*** The study investigates the predictive potential of the Rapid Neurodevelopmental Assessment (RNDA) and Prechtl's Method of Qualitative Assessment of General Movement (GMsA) in high-risk neonates. ***Method:*** This longitudinal cohort study at Dhaka Shishu Hospital (January 2016-December 2017) enrolled 16 high-risk neonates. GMsA and RNDA were conducted from birth to 20 weeks post-term age. Muscle tone, primitive reflexes, gross and fine motor skills were evaluated. Impending CP diagnosis was at 1 year. Statistical analysis was performed using SPSS 23.0. ***Results:*** The study investigates the association between various developmental markers and the risk of cerebral palsy (CP) in infants. Results reveal a higher prevalence of muscle tone impairment in impending CP cases across preterm, term, and post term ages. Sensitivity, specificity, and predictive values for CP prediction based on muscle tone are presented, showing significant associations. Primitive reflexes also demonstrate higher impairment rates in impending CP cases across different age points, with corresponding sensitivity, specificity, and predictive values. Gross motor and fine motor impairments exhibit significant associations with impending CP, along with predictive values. The distribution of categorical scores for GMsA and RNDA across various age points emphasizes the prevalence of impairments in impending CP cases. Findings indicate a strong association between GMsA scores and CP risk, with significant predictive capabilities across different visits. Overall, the study highlights the utility of these developmental markers in predicting CP risk in Neonates, emphasizing the importance of early assessment and intervention. ***Conclusion:*** RNDA and GMsA are valuable tools for CP prediction in high-risk neonates. Muscle tone, primitive reflexes, and motor impairments correlate with CP development. GMsA shows high sensitivity and specificity in CP prediction. Early intervention guided by RNDA and GMsA could optimize functional outcomes in high-risk neonates. Further research is warranted to enhance predictive models and intervention strategies.

Keywords: Cerebral palsy, Prechtl's Method, GMsA, Rapid Neurodevelopmental Assessment, (RNDA).

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INTRODUCTION

Cerebral palsy (CP) is a common motor disorder that affects infants and children, causing lifelong impairments in movement and posture. Early identification and prediction of CP and other motor developmental trajectories in high-risk neonates are crucial for timely interventions and improved outcomes. In recent years, the use of comprehensive assessment tools has gained prominence in the field of pediatric neurology, aiding in the early identification of neurodevelopmental disorders.

In conjunction with the RNDA, Prechtl's Method of Qualitative Assessment of General Movement (GMs) has emerged as a valuable tool for predicting CP and other developmental outcomes. GMs are spontaneous, writhing, and fidgety movements exhibited by infants during the first few months of life. Prechtl's method involves video analysis of these movements to assess their quality, symmetry, and complexity. Abnormalities in GMs have been videotaped and linked to a higher risk of CP and other neurodevelopmental disorders, making this method a valuable predictive tool [1-4].

Combining the RNDA and Prechtl's Method allows for a comprehensive evaluation of motor development in high-risk neonates. The early identification of CP and other motor developmental trajectories can facilitate early intervention strategies, including physical therapy, occupational therapy, and medical management, to optimize the infant's functional outcomes [5-7].

This study aims to explore the utility of the RNDA and Prechtl's Method in predicting CP and other motor developmental trajectories in high-risk neonates. We will review the existing literature on these assessment tools, highlighting their accuracy, reliability, and clinical implications. Furthermore, we will discuss the potential challenges and limitations associated with their implementation and suggest areas for future research to enhance their predictive value.

Objective

In this study our main goal is to evaluate the Prediction of Cerebral Palsy and Other Motor Developmental Trajectories in High-Risk Neonate Using the Rapid Neurodevelopmental Assessment (RNDA) and Prechtl's Method of Qualitative Assessment of General Movement.

METHOD

This longitudinal cohort study was carried out at Dhaka Shishu (Children) hospital from January 2016-December 2017. A total of 16 patients were enrolled in study group because of time constrain and avoiding patients who came from long distances. All infants with a gestational age below 37 weeks were included. These videos were anonymized and were viewed by two independent raters so they were blinded from knowledge the group from which each neonates belong to. Neurologic development is systematically followed from birth to 12 month of age with the Prechtl's method of qualitative assessment of GMs from birth to 20 weeks of PTA and rapid neurodevelopmental assessment tool from birth. For the purpose of the present study, the results of GMs and RNDA at term and post term age and the 12 months clinical motor and neurological examination in infant were compared.

Data was collected in a pre-set questioner and subjected to statistical analysis according to standard procedure. Statistical analysis was performed by using Statistical Package for Social Sciences version 23.0 for Windows (SPSS, Chicago, IL). Results of the findings was verified by standard test for significance like chi square test and Statistical significance was define as p<0 .05.

RESULTS

Table I: Observed outcome from RNDA: Association between muscle tone with final outcome (n=16)

Muscle tone	impending CP (n=7)		Suspected healthy child (n=9)		OR 95% CT	*p* Value
	n	%	n	%		
Preterm age (up to 40 weeks PMA)					0.75 (0.02-35.46)	0.700[ns]
Impaired	6	85.71	8	88.89		
Normal	1	14.29	1	11.11		
Term age (up to 45 weeks PMA)					-	0.011[s]
Impaired	7	100.00	3	33.33		
Normal	0	0.00	6	66.67		
Postterm age (5-20 weeks PTA)					48.00 (1.71-100)	0.001[s]
Impaired	6	85.71	1	11.11		
Normal	1	14.29	8	88.89		

*CP was diagnosed at 1 year by clinical motor and neurological exam at GDA clinic.
s= significant
ns= not significant
p Value reached from chi square test

Table I shows association between muscle tone with final outcome, it was observed that impending CP were 7 cases where impairment was mostly found in preterm, term and postterm age, among them 6(85.71%) in preterm age, 7(100.00%) in term age and 6(85.71%) in postterm age.

Table II: Sensitivity, specificity, accuracy, positive and negative predictive values of the Muscle tone for prediction of CP at 1 year of age

Muscle tone	1st	2nd	3rd
Sensitivity	85.7	100.0	85.7
Specificity	11.1	66.7	88.9
Accuracy	43.8	81.3	87.5
Positive predictive value	42.9	70.0	85.7
Negative predictive value	50.0	100.0	88.9

The validity test of muscle tone for prediction of CP has sensitivity 85.7%, specificity 11.1%, accuracy 43.8%, positive predictive values 42.9% and negative predictive value 50% in 1st visit. Sensitivity 100%, specificity 66.7%, accuracy 81.3%, positive predictive values 70% and negative predictive value 100% in 2nd visit. Sensitivity 85.7%, specificity 88.9%, accuracy 87.5%, positive predictive values 85.7% and negative predictive value 88.9% in 3rd visit.

Table III: Association between Primitive reflexes and final outcome in different visits (n=16)

Primitive reflexes	Impending CP (n=7)		Suspected healthy child (n=9)		OR 95% CT	*p* Value
	n	%	n	%		
Preterm age (up to 40 weeks PMA)					0.50 (0.04-6.16)	0.451ns
Impaired	2	28.57	4	44.44		
Normal	5	71.43	5	55.56		
Term age (up to 45 weeks PMA)					6 (0.33-100)	0.192ns
Impaired	3	42.86	1	11.11		
Normal	4	57.14	8	88.89		
Postterm age (5-20 weeks PTA)					20(0.99-100)	0.024s
Impaired	5	71.43	1	11.11		
Normal	2	28.57	8	88.89		

s= significant
ns= not significant
p Value reached from chi square test

Table shows association between primitive reflexes with final outcome, it was observed that impending CP were 7 cases, among them impairment was found in 2(28.57 %) in preterm age, 3(42.86 %) in term age and 5(71.43 %) in postterm age.

Table IV: Sensitivity, specificity, accuracy, positive and negative predictive values of the Primitive reflex for prediction of CP at 1 year of age

Primitive reflex	1st	2nd	3rd
Sensitivity	28.6	42.9	71.4
Specificity	55.6	88.9	88.9
Accuracy	43.8	68.8	81.3
Positive predictive value	33.3	75.0	83.3
Negative predictive value	50.0	66.7	80.0

The validity test of primitive reflex for prediction of CP has sensitivity 28.6%, specificity 55.6%, accuracy 43.8%, positive predictive values 33.3% and negative predictive value 50% in 1st visit. Sensitivity 42.9%, specificity 88.9%, accuracy 68.8%, positive predictive values 75.0% and negative predictive value 50.0% in 2nd visit. Sensitivity 71.4%, specificity 88.9%, accuracy 81.3%, positive predictive values 83.3% and negative predictive value 80.0% in 3rd visit.

Table V: Association between Gross motor with final outcome in different visits (n=16)

Gross motor	Impending CP (n=7)		Suspected healthy child (n=9)		OR 95% CT	*p* Value
	n	%	n	%		
Preterm age (up to 40 weeks PMA)					-	0.150ns
Impaired	7	100.00	6	66.67		
Normal	0	0.00	3	33.33		

Gross motor	Impending CP (n=7)		Suspected healthy child (n=9)		OR 95% CT	*p* Value
	n	%	n	%		
Term age (up to 45 weeks PMA)					-	0.150[ns]
Impaired	7	100.00	6	66.67		
Normal	0	0.00	3	33.33		
Post term age (5-20 weeks PTA)					48.00 (1.71-100)	0.001[s]
Impaired	6	85.71	1	11.11		
Normal	1	14.29	8	88.89		

s= significant
ns= not significant
p Value reached from chi square test

Table V shows association between Gross motor impairment with final outcome in different visits, it was observed that impending CP were 7 cases, among them gross motor impairment was present 7(100.00%) in preterm age, 7(100.00%) in term age and 6(85.71%) in post term age.

Table VI: Sensitivity, specificity, accuracy, positive and negative predictive values of the Gross motor impairment for prediction of CP at 1 year of age (n=16)

Gross motor	1st	2nd	3rd
Sensitivity	100.0	100.0	85.7
Specificity	33.3	33.3	88.9
Accuracy	62.5	62.5	87.5
Positive predictive value	53.8	53.8	85.7
Negative predictive value	100.0	100.0	88.9

The validity test of primitive reflex for prediction of CP has sensitivity 100%, specificity 33.3%, accuracy 62.5%, positive predictive values 53.8% and negative predictive value 100% in 1st visit. Sensitivity 100%, specificity 33.3%, accuracy 62.5%, positive predictive values 53.8% and negative predictive value 100% in 2nd visit. Sensitivity 85.7%, specificity 88.9%, accuracy 87.5%, positive predictive values 85.7% and negative predictive value 88.9% in 3rd visit.

Table VII: Association between Fine motor with final outcome in different visits (n=16)

Fine motor	Impending CP (n=7)		Suspected healthy child (n=9)		OR 95% CT	*p* Value
	n	%	n	%		
Preterm age					20.00(0.99-100)	0.024[s]
Impaired	5	71.43	1	11.11		
Normal	2	28.57	8	88.89		
Term age					2.00 (0.16-27.53)	0.451[ns]
Impaired	5	71.43	5	55.56		
Normal	2	28.57	4	44.44		
Postterm age					20.00 (0.99-100)	0.024[s]
Impaired	5	71.43	1	11.11		
Normal	2	28.57	8	88.89		

s= significant
ns= not significant
p Value reached from chi square test

Table VII shows association between Fine motor impairment with final outcome in different visits, it was observed that impending CP were 7 cases, among them 5(71.43%) in preterm age, 5(71.43%) in term age and 5(71.43%) in post term age.

Table VIII: Sensitivity, specificity, accuracy, positive and negative predictive values of the Fine motor impairment for prediction of CP at 1 year of age (n=16)

Fine motor	1st	2nd	3rd
Sensitivity	71.4	71.4	71.4
Specificity	88.9	44.4	88.9
Accuracy	81.3	56.3	81.3

Fine motor	**1st**	**2nd**	**3rd**
Positive predictive value	83.3	50.0	83.3
Negative predictive value	80.0	66.7	80.0

The validity test of primitive reflex for prediction of CP has sensitivity 71.4%, specificity 88.9%, accuracy 81.3%, positive predictive values 83.3% and negative predictive value 80.0% in 1st visit. Sensitivity 71.4%, specificity 44.4%, accuracy 56.3%, positive predictive values 50.0% and negative predictive value 66.7% in 2nd visit. Sensitivity 71.4%, specificity 88.9%, accuracy 81.3%, positive predictive values 83.3% and negative predictive value 80.0% in 3rd visit.

Table IX: Distribution (%) of categorical score for general movement assessment and RNDA at Preterm, term and posterm age point (n=16)

GMsA	**Preterm age n(%)**	**Term age n(%)**	**Post term age n(%)**	**Impending CP, n(%)**	**P value**
Normal	5(31.25)	9(56.25)	9(56.25)	0(0.0)	
Abnormal					
PR	6(37.5)	1(6.25)	-	0	
-CS	5(31.25)	6(37.5)	-	0	0.007s
-Ch	0	0	-	0	
-F	-	-	7(43.75)	7(43.75)	
RNDA					
Gross motor:					
Normal	9(56.25)	3(18.25)	9(56.25)	-	0.047s
Abnormal	7(43.75)	13(81.75)	7(43.75)	7(43.75)	
Fine motor					
Normal	10(62.5)	6(37.5)	10(62.5)	-	0.261ns
Abnormal	6(37.5)	10(62.5)	6(37.5)	7(43.75)	
Primitive reflexes					
Normal	12(75.0)	10(62.5)	10(62.5)	-	0.687ns
Abnormal	4(25.0)	6(37.5)	6(37.5)	7(43.75)	
Muscle tone					
Normal	6(37.5)	2(12.5)	9 (56.25)	-	0.034s
Abnormal	10(62.5)	14(87.25)	7(43.75)	7(43.75)	

Table IX shows association between categorical score for GMsA and RNDA with Preterm, term and posterm age point, it was observed that PR were 6(37.5%) and 1(6.25%) in preterm and term age respectively. CS was 5(31.25%) in preterm and 6(37.5%) in term age. Fidgety movement was absent in 7(43.75%) in postterm age. Gross motor impairment was found in 7(43.75%) in preterm, 13(81.75%) in term and 7(43.75%) in postterm age. Fine motor abnormality was found in 6(37.5%) in preterm, 10(62.5%) in term and 6(37.5%) in postterm age. Primitive reflexes abnormal was found 4(25.0%) in preterm, 6(37.5%) term and 6(37.5%) in postterm age. Muscle tone abnormal was found 10(62.5%) in preterm, 14(87.25%) term and 7(43.75%) in postterm age.

Table X: Association between GMsA with final outcome in different visits (n=16)

GMsA	**Impending CP (n=7)**		**Suspected healthy child (n=9)**		**OR 95% CT**	***p* Value**
	n	**%**	**n**	**%**		
Preterm					-	0.029s
Impaired	7	100.00	4	44.44		
Normal	0	0.00	5	55.56		
Term					-	0.001s
Impaired	7	100.00	0	0.00		
Normal	0	0.00	9	100.00		
Post term					-	0.001s
Impaired	7	100.00	0	0.00		
Normal	0	0.00	9	100.00		

s= significant
ns= not significant
p Value reached from chi square test

Table X shows association between GMsA with final outcome in different visits, it was observed that impending CP were 7 cases where impairment was found all of them 7 (100%) in preterm, term and postterm. suspected healthy child were 9 cases, among them impairment was present in 4(44.44%) in preterm visit no impairment found in term and postterm. The differences among preterm, term and postterm were statistically significant ($p<0.05$) between two groups.

Table XI: Sensitivity, specificity, accuracy, positive and negative predictive values of the GMsA for prediction of CP at 1 year of age (n=16)

GMsA	1st visit	2nd visit	3rd visit
Sensitivity	100.0	100.0	100.0
Specificity	55.6	100.0	100.0
Accuracy	75.0	100.0	100.0
Positive predictive value	63.6	100.0	100.0
Negative predictive value	100.0	100.0	100.0

The validity test of primitive reflex for prediction of CP has sensitivity 100%, specificity 55.6%, accuracy 75.0%, positive predictive values 63.6% and negative predictive value 100% in 1st visit. Sensitivity 100%, specificity 100%, accuracy 100%, positive predictive values 100% and negative predictive value 100% in 2nd visit. Sensitivity 100%, specificity 100%, accuracy 100%, positive predictive values 100% and negative predictive value 100% in 3rd visit.

DISCUSSION

Among the research participants, a correlation between muscular tone and CP suspicions across visits was statistically significant. In terms of sensitivity, specificity, accuracy, positive predictive values, and negative predictive values, the RNDA validity test that focuses on muscular tone, primitive reflex, gross motor, and fine motor development for CP prediction is on par with the preceding group.

Previous research has shown that high-risk infants benefit from serial longitudinal assessments of motor development, and now we know that the RNDA and GMsA at three age points predict motor impairment in both preterm and term infants [8-9]. Similarly, at the one-year mark, a number of babies whose RNDA diagnoses were motor delay actually showed normal motor outcomes. Results were similar in a study that followed 10 babies with CP for their first year of life and administered the AIMS at 3,6,9, and 12 months. While their research found an increasing frequency of babies with CP who were categorized as delayed in infancy as they got older, our study found the opposite to be true [10]. The predictive power of the NSMDA at 1,4, and 8 months in a group of 26 babies subsequently diagnosed with CP was the subject of another investigation [10]. Findings were consistent with the present research in that they demonstrated that prediction became better with time, with over-identification of newborns occurring at 4 months. When it comes to individuals suspected of having CP, our research lends credence to the usage of RNDA beginning at 2 weeks. This further demonstrated the value of reevaluating results at a later age. Additionally, while motor issues may become apparent with time, it is not advisable to dismiss babies from follow-up at 3 months of age after a normal evaluation if they are at high risk of subsequent motor deficits but perform within the normal range.

Concurrent validity with the neurological test has been shown in validation studies of the GMsA to be good [11-13]. The GMsA's contemporaneous validity with more conventional newborn and infant neurobehavioral and motor evaluations is the subject of another investigation [14]. Using baseline GMsA as a predictor of CP, this research found a statistically significant correlation and achieved 100% sensitivity across all follow-up visits.

It is the evaluation's context and intended results that should guide the choice of assessment technique. There is no evidence that GMsA is beneficial in intervention program design, while it does predict outcomes at postterm age in NICU survivors. Predictive validity has been reported by the AIMS, although the precision range for school-aged outcomes is restricted, and there is little evidence of intervention responsiveness [14-15].

Seven patients did not exhibit fidgety movement; nonetheless, all seven were identified as having imminent CP on RNDA, and they had impairment in several domains. The results showed a GM-outcome correlation of 0.70, which was statistically significant ($p<0.001$). 16 of 799 newborns with typical fidgetiness, 87% had a normal result, 13% had an MD, and 1% had a CP. There was no normal development in any of the 49 babies with aberrant fidgety; 88.0% had an MD and 12.0% a CP. None of the 55 babies who lacked fidgety demonstrated typical development; five of them had CPs and nine in ten had MDs. Overall, the 3-month GMs evaluation demonstrated a sensitivity of 98% and specificity of 94% for the development of CP when comparing normal fidgety to aberrant or nonexistent fidgety. A significant connection ($p<0.001$) was also discovered by the scientists between the HINE score and outcome ($rs=0.47$). A strong connection ($p<0.001$) was seen between GMs and RNDA.

In a small group of premature babies, this research is the first to compare a conventional neurological exam with GMs evaluation at 3 months. Both of these neurologic evaluation tools were shown to be very predictive of outcomes for premature babies in the current investigation. Overall, the sensitivity and specificity of the three-month RNDA were lower than those of the GMs evaluation in predicting CP development. The fact that RNDA is less useful for preterm evaluations could explain why. This was also the result of an earlier research that contrasted GMs evaluation with neurologic testing in premature babies [15].

Additionally, a study comparing the GMs assessment and the Amiel-Tison neurologic examination in 45 premature infants with varying degrees of neurologic risk found that both had a high sensitivity and negative predictive value, with the GMs assessment having a lower specificity and positive predictive value [16].

However, this research only looked at outcomes before 12 months, so it's possible that the results aren't reliable—particularly for kids who don't end up with CP. Since only seven out of sixteen children who did not exhibit the fidgety pattern at three months did not go on to acquire CP, this research confirms that the lack of FMs is a highly specific indicator of CP. Already at 3 months, the relevance of displaying FMs was shown in the biggest research conducted so far, which included 130 newborns. There was a subsequent development of CP in 98% of the babies in the research who did not exhibit a fidgety tendency [17].

Despite being a highly specific diagnostic of CP, the quality of FMs at 3 months cannot predict the subtype or severity of CP [18]. Regarding this matter, Prechtl's technique might provide helpful clues just via first-month longitudinal assessments that investigate several other features of spontaneous motility, including the existence of additional segmental movements [12]. It is currently unclear how much specialized knowledge is required to accurately interpret these new components of spontaneous behavior, and longitudinal exams aren't always feasible, particularly in low-risk preterm children. More conventional neurologic exams, which provide quantitative assessments of neurologic development, may be useful in distinguishing between newborns at risk for various forms of CP, according to the findings of another research [11].

It found that the combination of two distinct methods of neurologic evaluation was very beneficial. Our findings show that early detection of CP is not difficult using the usual neurological examination. In contrast, examination of GMs revealed the lack of FMs in all instances but one, strongly indicating CP.

This research demonstrated that even in a large follow-up program with newborns at low risk, atypical fidgeting should prompt a thorough evaluation of the child's development, even in the absence of obvious neurological symptoms. Differentiating between mild impairments may be helped by integrating it with a more conventional neurological evaluation that gives more quantitative information. Nevertheless, more research including long-term results are necessary to provide conclusive evidence, once the occurrence of mild neurologic dysfunctions is well understood.

CONCLUSION

For both full-term and premature infants, RNDA is a reliable indicator of cerebral palsy. In neonates at high risk for cerebral palsy, GMsA is also an excellent predictor. The third appointment was mostly used to rule out cerebral palsy. According to the results of this research, it is crucial to monitor all children who are at high risk for cerebral palsy in order to intervene often and appropriately, improving functional outcomes.

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