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Prediction of Cerebral Palsy and Other Motor Developmental Trajectories in High-Risk Neonate Using the Rapid Neurodevelopmental Assessment (RNDA)

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Abstract

Background: Cerebral Palsy (CP) is a prevalent motor disability affecting children globally, emphasizing the need for early identification and intervention. The Rapid Neurodevelopmental Assessment (RNDA) offers a comprehensive approach to predict CP and other motor developmental trajectories in high-risk neonates. ***Objective:*** This longitudinal cohort study aims to evaluate the effectiveness of RNDA in predicting CP and motor developmental trajectories. ***Method:*** Seventy term neonates from Dhaka Shishu (Children) Hospital were included, with neurodevelopmental assessments conducted using RNDA. Assessments were performed at 3 months and 6-9 months, with CP evaluation at 12 months using clinical examinations. ***Results:*** Prolonged labor (44.3%) and delayed cry after birth (31.4%) were common among the study patients (n=70), with varying modes of delivery including normal vaginal delivery (50.0%), vaginal delivery with complications (12.9%), and lower uterine cesarean section (37.1%). Muscle tone, primitive reflexes, gross and fine motor skills, epilepsy, and microcephaly were evaluated across visits to identify impending CP. Significant associations were found between hypertonicity, primitive reflex impairment, gross motor impairment, and fine motor impairment with impending CP across visits, particularly in the 3rd visit ($p<0.05$). Sensitivity, specificity, accuracy, and predictive values varied across parameters and visits, with fine motor skills and gross motor skills showing the highest sensitivity in the 3rd visit (86.4% and 100.0%, respectively). Additionally, abnormal EEG, USG of the brain, and MRI findings were significantly associated with impending CP, with USG of the brain demonstrating the highest sensitivity (93.3%) and MRI showing the highest specificity (70.0%). ***Conclusion:*** RNDA emerges as a valuable tool for early prediction of CP and motor developmental trajectories in high-risk neonates. Early identification through RNDA facilitates timely interventions, optimizing long-term neurodevelopmental outcomes.

Keywords: Cerebral Palsy, Rapid Neurodevelopmental Assessment (RNDA), High-risk Neonates, Motor Development, Early Intervention.

INTRODUCTION

Cerebral Palsy (CP) stands as one of the most prevalent motor disabilities affecting children worldwide, characterized by impaired movement and posture. Early identification and intervention are crucial in managing CP and improving long-term outcomes. The Rapid Neurodevelopmental Assessment (RNDA) emerges as a promising tool for predicting CP and other motor developmental trajectories in high-risk neonates. This innovative assessment offers a comprehensive evaluation of neurodevelopmental markers, allowing clinicians to identify subtle signs of motor impairment in the early stages of infancy [1-5].

High-risk neonates, including those born prematurely or with low birth weight, face increased vulnerability to neurodevelopmental challenges, including CP. The RNDA provides a structured approach to assess various domains of motor function, including muscle tone, primitive reflexes, gross and fine motor skills, enabling clinicians to detect deviations from typical motor development patterns. By integrating clinical observation with standardized assessment measures, the RNDA offers valuable insights into the neurodevelopmental status of high-risk neonates, facilitating early intervention strategies to optimize outcomes [6-10].

Understanding the predictive value of the RNDA in identifying CP and other motor developmental trajectories is essential for guiding clinical practice and intervention strategies. By harnessing the power of early assessment and intervention, healthcare providers can mitigate the impact of motor disabilities on the lives of high-risk neonates, promoting optimal neurodevelopmental outcomes.

OBJECTIVE

To assess the effectivity of prediction of cerebral palsy and other motor developmental Trajectories in high-risk neonate using the rapid neurodevelopmental assessment (RNDA).

METHOD

This longitudinal cohort study was carried out at Dhaka Shishu (Children) hospital from January 2016-December 2017 where 70 term neonates fulfilling the selection criteria was included in the present study. An informed written consent was taken from parents to include the child in the study. Neurodevelopmental assessment was done by Rapid Neurodevelopmental Tools in all high-risk neonates. Cases was sorted out on the basic of normal and abnormal RNDA findings on discharge. Again children was assessed at their 3 months and once in 6 -9 months of age and finally assess for CP at 12 months of age using clinical motor and neurological examination in infant

RESULTS

Table I: Distribution of the study patients by perinatal history and mode of delivery (n=70)

Perinatal history	**n=70**	
	n	**%**
Prolonged Labour	31	44.3
Prolong labour & delayed cry after birth	22	31.4
Normal perinatal history	0	0.0
Mode of delivery		
NVD	35	50.0
VD with complications	9	12.9
LUCS (emergency)	26	37.1

*LUCS= Lower uterine cesarian section

Table I shows perinatal history and mode of delivary of the study patients, it was observed 44.3% patients had prolonged Labour in study group followed by 31.4% prolong labour & delayed cry after birth.

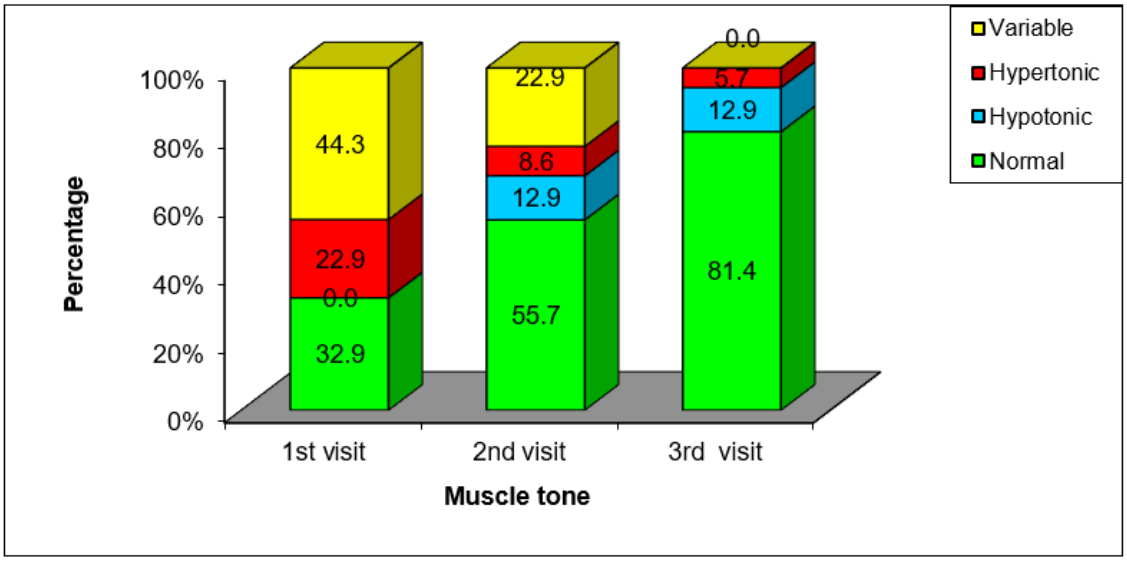

Figure 1: Bar diagram shows Muscle tone of the study subjects in different visit

It was observed that 16(22.9%) patient had hypertonic in 1st visit and 4(5.7%) in 3rd visit. The difference was statistically significant ($p<0.05$) in 1st visit and 3rd visit. It was also observed that 6(8.6%) patient was hypertonic in 2nd visit and 4(5.7%) in 3rd visit. The difference was statistically significant ($p<0.05$) in 2nd visit and 3rd visit.

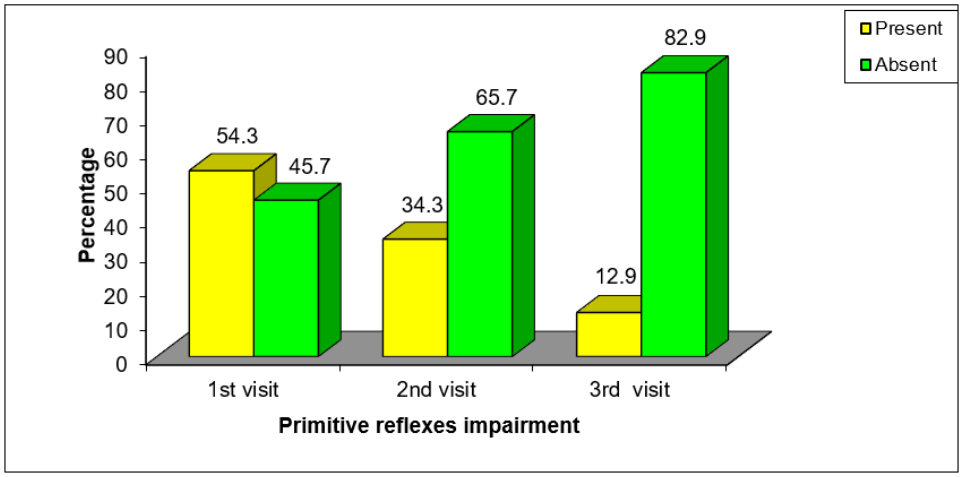

Figure 2: Bar diagram shows primitive reflexes impairment of the study subjects

It was observed that more than half (54.3%) patient had present in 1st visit and 9(12.9%) in 3rd visit. The difference was statistically significant ($p<0.05$) in 1st visit and 3rd visit. Besides 24 (34.3%) patient had present in 2nd visit and 9(12.9%) in 3rd visit. The difference was statistically significant ($p<0.05$) in 2nd visit and 3rd visit.

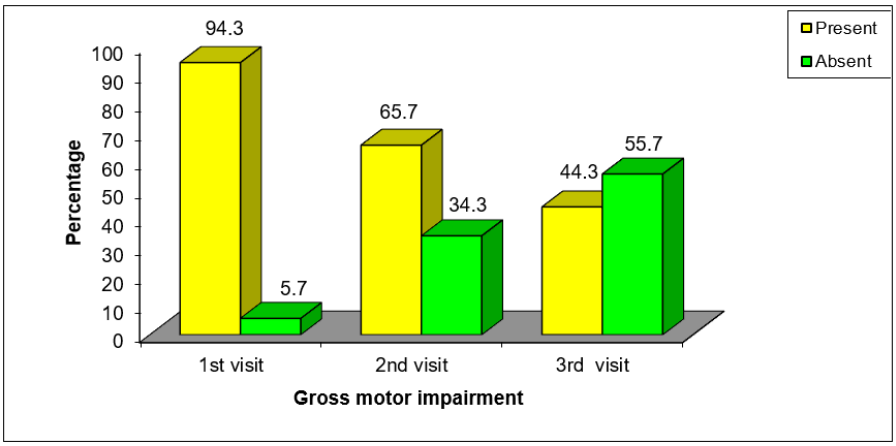

Figure 3: Bar diagram shows Gross motor impairment of the study subjects

It was observed that 66(94.3%) patient had impairment in 1st visit and 31(44.3%) in 3rd visit. The difference was statistically significant ($p<0.05$) in 1st visit and 3rd visit. Besides 46(65.7%) patient had impairment in 2nd visit and 31(44.3%) in 3rd visit. The difference was statistically significant ($p<0.05$) in 2nd visit and 3rd visit.

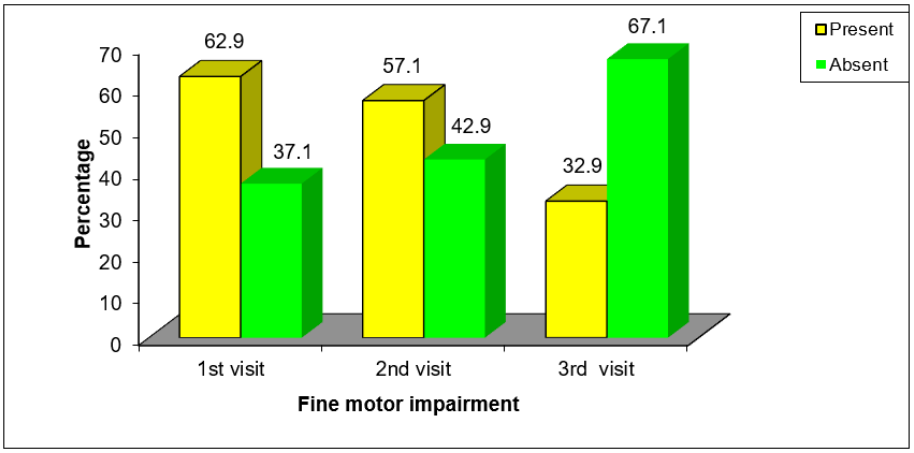

Figure 4: Bar diagram shows Fine motor impairment of the study subjects

It was observed that 44(62.9%) patient had impairmentt in 1st visit and 23(32.9%) in 3rd visit. The difference was statistically significant (p<0.05) in 1st visit and 3rd visit. Besides 40(57.1%) patient had fine motor impairment in 2nd visit and 23(32.9%) in 3rd visit. The difference was statistically significant (p<0.05) in 2nd visit and 3rd visit.

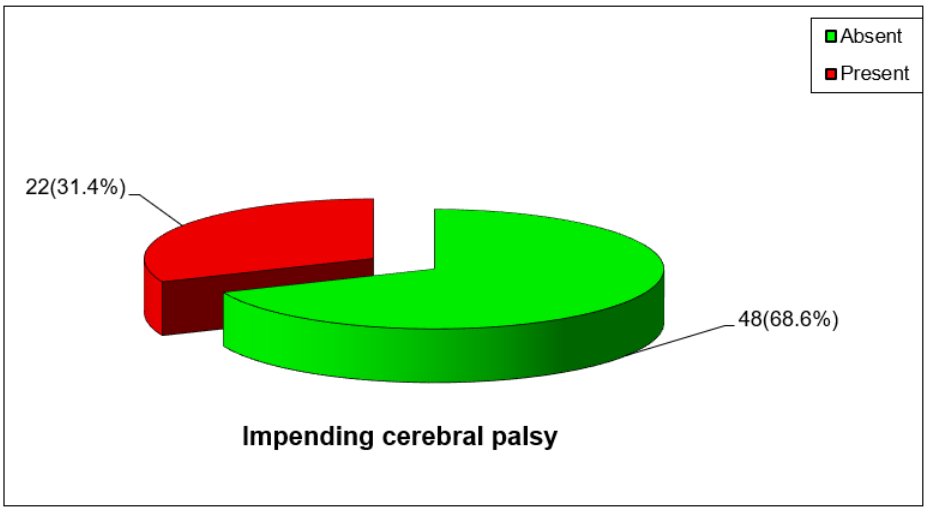

Figure 5: Pie chart shows impending cerebral palsy of the study subjects

It was observed that more than one fourth (31.4%) patients identified as impending cerebral palsy, 10(14.3%) not known and 38(54.3%) was apparently normal.

Table II: Observed outcome from RNDA and neurological examination: Association between muscle tone with final outcome in different visits (n=70)

Muscle tone	Impending CP (n=22)		Healthy child (n=48)		*p* Value
	n	%	n	%	
1st visit					
Hypertonic	6	27.2	10	20.8	0.745ns
Variable	10	45.5	21	43.8	
Normal	6	27.3	17	35.4	
2nd visit					
Hypertonic	4	18.2	2	4.2	0.001s
Hypotonic	3	13.6	6	12.5	
Variable	11	50.0	5	10.4	
Normal	4	18.2	35	72.9	
3rd visit					
Hypertonic	4	18.2	0	0.0	0.001s
Hypotonic	5	22.7	4	8.3	
Normal	13	59.1	44	91.7	

s= significant

p Value reached from chi square test

It was observed that impending CP were 22 cases, among them hypertonic was 6(27.2%) in 1st visit, 4(18.2%) in 2nd visit and 4(18.2%) in 3rd visit. Healthy child were 48 cases, among them hypertonic was 10(20.8%) in 1st visit, 2(4.2%) in 2nd visit and 0(0.0%) in 3rd visit. The difference was statistically significant (p<0.05) 2nd and 3rd visit between two groups.

Table III: Association between primitive reflexes with final outcome in different visits (n=70)

Primitive reflexes	Impending CP (n=22)		Healthy child (n=48)		OR 95% CI	*p* Value
	n	%	n	%		
1st visit					1.33(0.43-4.18)	0.584ns
Impairment	13	59.1	27	56.3		
No impairment	9	40.9	21	43.7		

2nd visit					2.69(.83-8.82)	0.061ns
Impairment	11	50	13	27.1		
No impairment	11	50	35	72.9		
3rd visit					19.17(3.23-100.78)	0.001s
Impairment	10	45.5	2	4.2		
No impairment	12	54.5	46	95.8		

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

Table shows association between baseline primitive reflexes with different visits, it was observed that impending CP were 22 cases where impairment had more common in 1st, 2nd and 3rd visit, among them 13(59.1%) in 1st visit, 11(50.0%) in 2nd visit and 10(45.5%) in 3rd visit. Healthy child were 48 cases, among them impairment had 27(56.3%) in 1st visit, 13(27.1%) in 2nd visit and 2(4.2%) in 3rd visit. The difference 3rd visit was statistically significant (p<0.05) between two groups.

Table IV: Sensitivity, specificity, accuracy, positive and negative predictive values of the Primitive reflexes for prediction of CP

Primitive reflexes	1st visit	2nd visit	3rd visit
Sensitivity	59.1	50.0	45.5
Specificity	47.9	72.9	95.8
Accuracy	51.4	65.7	80.0
Positive predictive value	34.2	45.8	83.3
Negative predictive value	71.9	76.1	79.3

The validity test of primitive reflexes for prediction of CP has sensitivity 59.1%, specificity 47.9%, accuracy 51.4%, positive predictive values 34.2% and negative predictive value 71.9% in 1st visit. Sensitivity 50.0%, specificity 72.9%, accuracy 65.7%, positive predictive values 45.8% and negative predictive value 76.1% in 2nd visit. Sensitivity 45.5%, specificity 95.8%, accuracy 80.0%, positive predictive values 83.3% and negative predictive value 79.3% in 3rd visit.

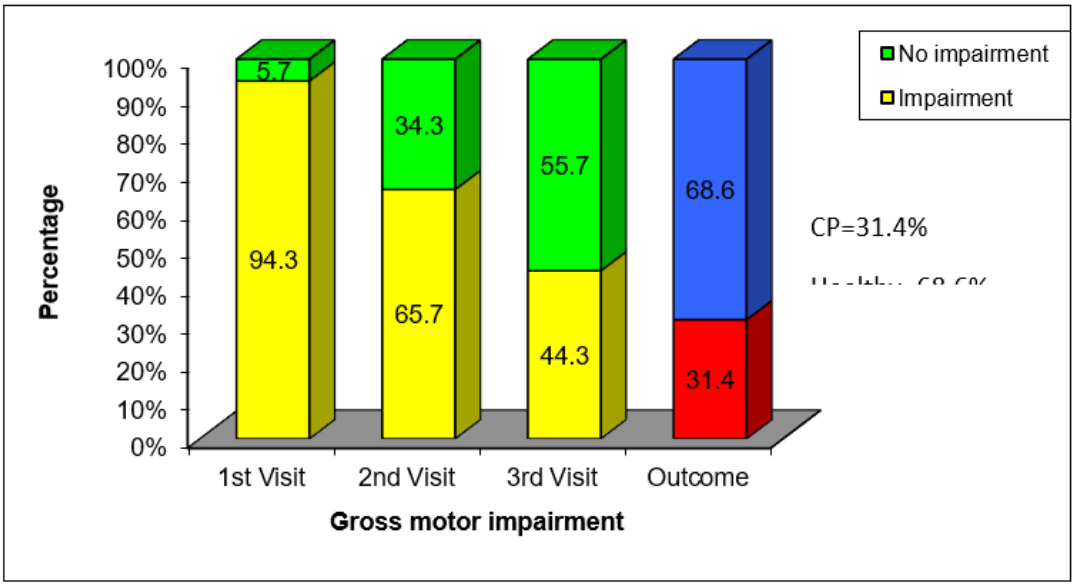

Figure 6: Bar diagram shows gross motor impairment in subsequent visit

Table V shows association between baseline gross motor with different visits, it was observed that impending CP were 22 cases where impairment had more common in 1st, 2nd and 3rd visit, among them 21(95.5%) in 1st visit, 21(95.5%) in 2nd visit and 22(100.0%) in 3rd visit. Healthy child were 48 cases, among them impairment had 45(93.7%) in 1st visit, 25(52.1%) in 2nd visit and 9(18.7%) in 3rd visit. The difference of 2nd and 3rd visit were statistically significant (p<0.05) between two groups.

Table V: Sensitivity, specificity, accuracy, positive and negative predictive values of the gross motor for prediction of CP

Gross motor	1st visit	2nd visit	3rd visit
Sensitivity	95.5	95.5	100.0
Specificity	6.3	47.9	81.3
Accuracy	34.3	62.9	87.1
Positive predictive value	31.8	45.7	71.0
Negative predictive value	75.0	95.8	100.0

The validity test of gross motor for prediction of CP has sensitivity 95.5%, specificity 6.3%, accuracy 34.3%, positive predictive values 31.8% and negative predictive value 75.0% in 1st visit. Sensitivity 95.5%, specificity 47.9%, accuracy 62.9%, positive predictive values 45.7% and negative predictive value 95.8% in 2nd visit. Sensitivity 100.0%, specificity 81.3%, accuracy 87.1%, positive predictive values 71.0% and negative predictive value 100.0% in 3rd visit.

Table VI: Association between fine motor impairment with final outcome in different visit (n=70)

Fine motor	Impending CP (n=22)		Healthy child (n=48)		OR 95% CI	*p* Value
	n	%	n	%		
1st visit					1.90(0.56-6.63)	0.247ns
Impairment	16	72.7	28	58.3		
No impairment	6	27.3	20	41.7		
2nd visit					5.32(1.39-21.99)	0.004s
Impairment	18	81.8	22	45.8		
No impairment	4	18.2	26	54.2		
3rd visit					69.67(11.82-514.34)	0.001s
Impairment	19	86.4	4	8.3		
No impairment	3	13.6	44	91.7		

s= significant
p Value reached from chi square test

Table shows association between baseline fine motor with different visits, it was observed that impending CP were 22 cases where impairment had more common in 1st, 2nd and 3rd visit, among them 16(72.7%) in 1st visit, 18(81.8%) in 2nd visit and 19(86.4%) in 3rd visit. Healthy child were 48 cases, among them impairment had 28(58.3%) in 1st visit, 22(45.8%) in 2nd visit and 4(8.3%) in 3rd visit. The difference in 3rd visit was statistically significant ($p<0.05$) between two groups.

Table VII: Sensitivity, specificity, accuracy, positive and negative predictive values of the Fine motor for prediction of CP

Fine motor	1st visit	2nd visit	3rd visit
Sensitivity	72.7	81.8	86.4
Specificity	41.7	54.2	91.7
Accuracy	51.4	62.9	90.0
Positive predictive value	36.4	45.0	82.6
Negative predictive value	76.9	86.7	93.6

The validity test of Fine motor for prediction of CP has sensitivity 72.7%, specificity 41.7%, accuracy 51.4%, positive predictive values 36.4% and negative predictive value 76.9% in 1st visit. Sensitivity 81.8%, specificity 54.2%, accuracy 62.9%, positive predictive values 45.0% and negative predictive value 86.7% in 2nd visit. Sensitivity 86.4%, specificity 91.7%, accuracy 90.0%, positive predictive values 82.6% and negative predictive value 93.6% in 3rd visit.

Table VIII: Association between epilepsy and microcephaly with different visits (n=70)

Epilepsy	Impending CP (n=22)		Healthy child (n=48)		OR 95% CI	*p* Value
	n	%	n	%		
Present	10	45.5	3	6.3	12.50(2.56-69.32)	0.001s
Absent	12	54.5	45	93.8		
Microcephaly						
Present	8	36.4	1	2.1	13.14(2.17-102.53)	0.001s
Absent	14	63.6	47	97.9		

s= significant
p Value reached from chi square test

Table shows association between epilepsy and microcephaly with different visit, it was observed that epilepsy was present 10(45.5%) patients in impending CP and 3(6.3%) in healthy child, microcephaly in 8(36.4%) patients in impending CP and 1(2.1%) in healthy child. The difference was statistically significant ($p<0.05$) between two groups.

Table IX: Association of EEG, USG of brain and MRI findings with final outcome

	Impending CP (n=16)		**Healthy child (n=21)**		**OR 95% CI**	***p* Value**
EEG findings	**n**	**%**	**n**	**%**		
Abnormal	12	75.0	4	19.0	12.75(2.15-88.97)	0.001[s]
Normal	4	25.	17	81.0		
USG of brain	**(n=15)**		**(n=29)**			
Abnormal	14	93.3	10	34.5	26.60(2.82-624.69)	0.001[s]
Normal	1	6.7	19	65.5		
MRI	**(n=5)**		**(n=10)**			
Abnormal	5	100.0	3	30.0	-	0.010[s]
Normal	0	0.0	7	70.0		

s= significant

p Value reached from chi square test

Table IX shows association of EEG, USG of brain and MRI findings with final outcome, it was observed that abnormal EEG findings found in 12(75.0%) patients in impending CP. USG of brain found abnormal in 14(93.3%) patients in impending CP. MRI found abnormal in 5(100.0%) patients in impending CP. The difference was statistically significant ($p<0.05$) between CP and healthy child.

Table X: Sensitivity, specificity, accuracy, positive and negative predictive values of the EEG, USG of brain and CT/MRI for prediction of CP

Validity test	**EEG**	**USG of brain**	**CT/MRI**
Sensitivity	75.0	93.3	100.0
Specificity	81.0	65.5	70.0
Accuracy	78.4	75.0	80.0
Positive predictive value	75.0	58.3	62.5
Negative predictive value	81.0	95.0	100.0

The validity test of EEG for prediction of CP has sensitivity 75.0%, specificity 81.0%, accuracy 78.4%, positive predictive values 75.0% and negative predictive value 81.0%. The validity test of USG of brain for prediction of CP has sensitivity 93.3%, specificity 65.5%, accuracy 75.0%, positive predictive values 58.3% and negative predictive value 95.0%. The validity test of CT/MRI for prediction of CP has sensitivity 100.0%, specificity 70.0%, accuracy 80.0%, positive predictive values 62.5% and negative predictive value 100.0%.

DISCUSSION

A collection of persistent abnormalities affecting movement and posture development, leading to activity restriction, known as cerebral palsy (CP), are thought to be caused by nonprogressive disturbances that happen in the developing brain of a fetus or child. Problems with walking, eating, eye coordination, speech articulation, and other musculoskeletal tasks may result from abnormalities in gross and fine motor functioning [11]. Infants with a very low birth weight develop cerebral palsy (CP) at a rate of 5-15%, and being born preterm (<37 weeks), very low birth weight (<1500 g/<32 weeks), or extreme low birth weight (< 1000 g/<28 weeks) is linked to severe motor disability. 9-11 Babies born very early (before 28 weeks) are at a much higher risk of brain damage because they are born while the brain is actively developing and maturing [12].

This prospective research was conducted in a hospital setting with the goals of identifying high-risk neonates at an earlier age for cerebral palsy (CP), learning about CP's motor development patterns, and identifying risk factors for CP. In addition to reducing limitations caused by CP, this research offers early intervention to lessen the prevalence of co-morbidities.

In this research, 70 high-risk newborns were enrolled from January 2016 to December 2017 at the Dhaka Shishu (Children) hospital's neonatal ward within the Pediatric Neuroscience department. The research did not include infants with known or suspected metabolic disorders, those with complicated and severe medical or surgical problems, or those with congenital brain or spinal cord abnormalities. The results of the current research were reviewed and contrasted with those of related studies that had been published earlier.

People in the research group were more likely to have labor that lasted longer and to weep later after giving delivery. Extensive and challenging work was indicated by 94% of the participants. Not only did some patients have low birth weight, but others cried poorly or late and did not need hospital resuscitation [13]. "Normal vaginal delivery without prolonged and difficult labor" was the mode of delivery reported by 96.3% of the women.

The current research found that whereas some participants showed considerable progress in subsequent visits, others exhibited persistent impairment in muscular tone, primitive reflex, gross motor, and fine motor skills throughout all visits. Additionally, about one-third of the individuals were found to have cerebral palsy. In a similar vein, cerebral palsy was diagnosed in 25.0% of the high-risk infants in their research [13]. Another research found that out of 606 individuals treated in the DFC, 46 (or 7.6% of the total) had CP diagnosed definitively; 32 of them were born preterm and 14 were either late preterm (LPT) or term. Babies born with low birth weight (LBW) had a 5.83-fold increased risk of cerebral palsy compared to babies born between 2500 and 4000 g (OR; 5.83 95% CI, 3.47 to 9.77), according to research by Li et al. (2011) [14].

The results of this research showed that CP in future visits may be predicted by muscular tone. When patients are monitored for 6 to 9 months, RNDA may help us identify those who are at high risk of developing expanding CP. Another research found that the RNDA showed strong concurrent validity in both rural and urban populations for older children, especially when it came to gross motor skills [15]. By analyzing muscle tone, primitive reflex gross motor, and fine motor skills, our longitudinal research found that RNDA may predict CP early on.

This work is groundbreaking since it is the first of its kind to document the use of RNDA for serial motor evaluation of infants in order to forecast their motor outcomes in later years. Different evaluation instruments revealed different rates of motor delay in infants. With data from all three evaluation sites, motor impairment at 1 year of age might be more accurately predicted. Combining findings from all evaluations at each time point further enhanced accuracy.

Because there are so many variables at play during a child's development, it is difficult to predict, using a single evaluation, whether or not the child will go on to develop cerebral palsy or another developmental disability. This is true in both clinical and research settings. 16 When communicating evaluation findings to families, it is crucial to take the infant's whole medical history into account. Additionally, sensitivity and specificity are often compromised when evaluating an evaluation tool's predictive usefulness. For instance, while using the MABC-2 to forecast motor impairment, the sensitivity dropped as the number of tests performed increased the specificity scores. Greater sensitivity is ideal for follow-up evaluations whose purpose is to identify children in need of early intervention. If the aim is to prevent services from being directed to those who do not have an impairment, however, a greater level of specificity is desirable. It is usually best to strike a balance between being too sensitive and being too particular.

A substantial connection between epilepsy and microcephali for the diagnosis of CP was found in this research. There was a strong correlation between probable instances of CP and EEG, USG of brain, and MRI results. For CP prediction, the CT/MRI validity test is more sensitive than the USG of the brain and the ECG. Cranial ultrasonography, MRI, and other imaging modalities can reliably anticipate the presence of severe CP in infants during the first few hours of life. For moderate to mild CP, this does not apply. It is possible to stratify newborns by risk and predict neuromotor impairment at 2 years of age from abnormal MRI results in high preterm infants at term-equivalent age [17]. The expense, accessibility, and competence needed to employ MRI in everyday practice are major limitations, however. Neonatal intensive care units often do cranial ultrasounds, and there is a robust link between serious lesions seen on these scans and MRI results in children of school age. 18 Although it has limited accuracy in diagnosing non-cystic lesions, newborn cranial ultrasonography is quite reliable for detecting intraventricular hemorrhage and cystic white matter damage (Inder *et al.*, 2003). Therefore, cranial ultrasonography's usefulness in forecasting newborns' neurodevelopmental outcomes is still up for debate. Rather than cerebral palsy, this is about cognitive growth [11]. It is true that a population-based research found a rather poor sensitivity to predict cerebral palsy [10].

When it comes to measuring neuromotor development, the RNDA has good reliability and validity [5]. According to the study's authors, the RNDA is a stable and dependable scale, and raters with understanding of neuromotor development may effectively use it regardless of their medical background. Further, as previously reported, the RNDA was shown to be time-saving during administration in this trial (mean time: 8 minutes).

For issues that parents had not yet noticed, the RNDA was a lifesaver. The "temporary" meaning impairment and the "permanent" meaning disability may have an important interface and time link. Maternal recollection was quite sensitive to severe disabilities in a number of underdeveloped nations, but it was insensitive to minor ones [3]. Both the RNDA's administration and efforts to raise parental knowledge of the latter have the potential to be educationally beneficial. Furthermore, all fifty high-risk newborns whose management was based on RNDA findings showed an improvement in the

severity of their functional impairments in a hospital-based 3-month follow-up [3].

CONCLUSION

In conclusion, the findings highlight the significance of the RNDA as a reliable and efficient tool for predicting CP and other motor developmental trajectories in high-risk neonates. Early identification and intervention based on neurodevelopmental assessments are essential for mitigating the impact of motor disabilities and improving long-term outcomes for vulnerable infants.

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