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Original Research Article

Rapid neurodevelopmental assessment of newborn: a promise to ensure proper growth and development of all newborns in Bangladesh

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ABSTRACT

Background: Neonates are susceptible to neurodevelopmental impairments due to various factors. The aim of the study was to use the n-RNDA tool to identify such impairments in neonates, enabling early interventions for improved outcomes.
Methods: This facility-based cross-sectional study was conducted in Square Hospital Child Development Center from April 2019 to Nov 2021 with all neonates between ages of 15-28 days. A total 2928 neonates were enrolled and underwent n-RNDA assessment for detection of any types of neurodevelopmental impairments.
Results: Among 2928 enrolled neonates, 8.1% exhibited neurodevelopmental impairments. Majority (60.6%) were from the NICU. Impairments varied across domains, with gross motor skills (99.2%) being most prevalent. Causes included respiratory distress syndrome (74%), sepsis (60%), and others. The study population was primarily urban (99.1%), with 100% parental literacy.
Conclusions: The n-RNDA screening program for neonates facilitates early assessment, interventions, and long-term follow-up, potentially enhancing outcomes and quality of life. These findings advocate for policy development to institutionalize n-RNDA for early diagnoses and better outcomes in all neonates.

Keywords: Neonates, Preterm, Neurodevelopment, Growth, Impairments, n-RNDA

INTRODUCTION

Rapid neurodevelopmental assessment is a crucial part of evaluating a neonate's neurological function. While neuroimaging and neurophysiology techniques have advanced our understanding of neurologic abnormalities, the clinical neurological examination is still a valuable tool for diagnosis. It is cost-effective, time-efficient, and can provide valuable information about a neonate's neurological status.[1]

A neonate, or newborn infant, is a child under 28 days of age. The neonatal period is a very important time for a child's development, as it is when they are at the highest risk of death. Unfortunately, the majority of newborn deaths occur in developing countries where access to healthcare is limited. It is important for neonates to receive proper medical care and support during this vulnerable time to improve their chances of survival and overall health.[2]

They can experience a variety of neurological problems that affect the brain, spinal cord, peripheral nerves, and muscles. While there are over 600 neurological disorders that can occur throughout a person's lifetime, fewer neurological conditions occur in neonates. These disorders can be present at birth or occur shortly after birth. The development of a baby's brain begins at fourth

week after conception and continues throughout pregnancy and after birth.

Some neurological conditions are congenital, meaning they are present before birth, while others may be caused due to prematurity, low birth weight, intrauterine growth retardation, trauma, perinatal asphyxia, congenital infection, inborn errors of metabolism, genetic disorders, epilepsy, tumors, and poor maternal health conditions. Regardless of the cause, all neurological disabilities result from damage to the nervous system, which can impact communication, vision, hearing, movement, and cognition to varying degrees depending on where the damage occurs.[3-10]

These factors can influence the development of a neonate's brain, including genetics and gene-environment interactions. These interactions begin at conception and can have short-term and long-term effects on brain development. During the first 1,000 days of life, the brain is particularly vulnerable to changes that can have lifelong impacts on development. A fetal/neonatal program (FNNP) that takes this perspective can better identify specific mechanisms that affect the maternal/placental/fetal (MPF) triad and how they manifest as brain malformations or destructive lesions. Maladaptive MPF triad interactions can impair the development of progenitor neurons and glial cells within transient brain structures due to processes such as maternal immune activation. Destructive fetal brain lesions later in pregnancy may be caused by ischemic placental syndromes associated with obstetrical complications. Trimester-specific MPF triad diseases may also negatively affect labor and delivery outcomes.[11-13]

Neonates can be at risk for neurological disorders during different periods in their development. These periods can be divided into three categories: antenatal, perinatal, and neonatal. In the antenatal period (before birth), neurological disorders can be inherited from one or both parents or can be caused by chromosomal abnormalities. Other contributing factors may include maternal health and toxin exposure, and complications during labor and delivery. Newborns may also be at risk for neurological disorders due to prematurity, low birth weight, intrauterine growth retardation, perinatal asphyxia, genetic disorders, and infections. During the perinatal period (during birth), neurological disorders can be caused by a lack of oxygen, infections in the mother's genital tract that are passed to the baby, or physical injuries to the head that may cause bleeding in the brain. In the neonatal period (after birth), neurological disorders can be caused by immune disorders, medical conditions, viral or bacterial infections like meningitis or encephalitis. It is important to identify and address these conditions early on to improve the chances of a positive outcome.[14]

Birth asphyxia is a common condition that can cause neurological problems in newborns. It occurs when a newborn infant does not receive enough oxygen before, during, or immediately after birth and can result in severe organ damage and potentially fatal outcomes or severe lifelong pathologies. This condition is more prevalent in developing countries, where access to proper medical care during childbirth may be limited. It is important to identify and treat birth asphyxia as early as possible to minimize the risk of serious complications.[15] Neonatal seizures, also known as neonatal convulsions, are epileptic fits that occur in newborns from birth to the end of the neonatal period. The neonatal period is the most vulnerable time for developing seizures, with the highest risk occurring in the first 1-2 days to the first week of life. It is important to identify and treat neonatal seizures as quickly as possible to prevent further complications and improve the chances of a positive outcome.[16] Encephalopathy means brain disease, disorder or damage. The term refers to temporary or permanent conditions that affect the brain's structure or function.[17]

Newborns may experience feeding and breathing difficulties and altered levels of consciousness due to neurological conditions such as intracranial hemorrhage or bleeding in the brain. One specific type of intracranial hemorrhage that can occur in newborns is intraventricular hemorrhage (IVH), which is bleeding into the fluid-filled areas or ventricles of the brain. This condition is most common in premature babies, who are at higher risk for IVH and the resulting neurological condition of periventricular leukomalacia. It is important to identify and treat these conditions as early as possible to minimize the risk of serious complications and improve the chances of a positive outcome.[18] Neonates with hypotonia, or low muscle tone, may have floppy muscles and appear limp. This condition is caused by a communication disorder in the pathways that connect the brain, spinal cord, nerves, and muscles and control movement. Hypotonia can be a symptom of various underlying neurological conditions and it is important to identify and address these conditions to improve the neonate's muscle tone and overall development.[19]

Neonates with congenital neurological defects may also experience difficulty with breathing and feeding. These defects are present at birth and are typically related to brain and spinal cord malformations. They can include structural or migrational malformations of the brain, such as neural tube defects. Neural tube defects are the most common severe central nervous system anomalies, second only to cardiovascular abnormalities, and can cause congenital morbidity and mortality. Folic acid supplementation as part of a multivitamin regimen has been shown to decrease the incidence rate of neural tube defects by 71%. It is important to identify and address congenital neurological defects as early as possible to improve the chances of a positive outcome.[20]

Metabolic disorders of the brain can affect brain function through a variety of biochemical reactions. Any

disruption in these processes can lead to changes in neurological function, some of which may be reversible and others not. One important cause of neonatal morbidity and mortality is arterial ischemic stroke in newborns, which is a type of stroke that occurs when the blood supply to a part of the brain is disrupted. It is important to identify and address metabolic disorders and other neurological conditions as early as possible to improve the chances of a positive outcome.[21]

The purpose of this study was to assess the neurological status of the neonates in order to identify any neurological impairment as early as possible and provide early intervention to improve their outcomes. To do this, this study used the neonatal Rapid Neurodevelopmental Assessment (n-RNDA) as a screening tool to identify neurodevelopmental impairments (NDIs) in all newborns in the hospital. NDIs are a term that encompasses a range of impairments, including cognitive, motor, sensory, behavioral, and psychological impairments. By identifying these impairments early on, it is possible to provide the necessary support and interventions to improve the neonate's outcomes and quality of life.[22]

METHODS

This facility based cross-sectional study was conducted at the Square Hospital Child Development Center (CDC), Dhaka, Bangladesh. Neonatal screening (n-RNDA) program was established for all neonates born in this hospital for the first time in Bangladesh. This hospital is one of the largest, well reputed tertiary care private Hospital. Inclusion criteria were all neonates born in this hospital and managed either in nursery or NICU. Data was collected from April 2019 to Nov 2021.

A total 2928 neonates were enrolled in this study and were examined between 15-28 days of age. A qualified multiprofessional team were engaged for taking detailed history of the neonate and neurodevelopmental assessment by applying neonatal "Rapid Neurodevelopmental Assessment" (n-RNDA) tool, a screening instrument for detection of neurodevelopmental impairments. An informed consent was also obtained from the legal guardians of the neonates. Participants whose guardians did not consent to the study were excluded from the study, as well as participants with other chronic ailments.

The neonatal neurodevelopmental assessment included a comprehensive history as well as the physical components of examination. General Information of the neonates and parents were taken such as name, gender, date of birth, chronological age in months, gestational age in weeks, age preterm in weeks, corrected age in months, mother's and father's name, date of examination, socioeconomic status, demographic history and parental education and occupation.

Family history (about siblings) included whether other siblings had birth defects, developmental delay, stillbirths or early unexpected deaths. Genetic history was included about consanguinity. Prenatal history included maternal illness, use of abortifacient or any other drugs during 1st trimester, threatened abortion, trauma, maternal stress, habitual abortion. Perinatal history included whether labour was prolonged or not, crying of the baby, any color change and was the baby small for date? Neonatal history included whether the baby had seizure, jaundice or any other medical condition. Baby was inspected for the nutritional status. Anthropometry measurement includes weight, length and head measurement (OFC).

General examination focused on nutrition, head, fontanelles, face, ear, nose, mouth, palate, tongue, upper extremity, lower extremity, muscle tone and spine. Neonatal neurological examination was done by assessing different domains of the neonate by applying n-RNDA tool which includes primitive reflexes, gross motor, fine motor, vision, hearing, speech, cognition and behavior. All collected data was analyzed using SPSS version 25, and ethical approval regarding the study was obtained from the ethical review committee of the study hospital.

RESULTS

The study enrolled a total of 2928 newborn infants, with 2824 (96.45%) coming from the nursery and 104 (3.55%) from the neonatal intensive care unit (NICU. There were 1542 male babies (52.7%) and 1386 female babies (47.3%), Preterm babies accounted for 18.4% of the study subjects, while 11.2% had low birth weight and 5.63% had intrauterine growth retardation, 45.8% were infants of diabetic mothers, 4.3% had sepsis, 1.7% had delayed crying and 2.3% had respiratory distress syndrome.

Among the 2928 newborns, 237 (8.1%) had neurodevelopmental impairments. The majority of these impairments were observed in infants came from the NICU (60.6%), while 6.16% were observed in infants from the nursery. The impairments included primitive reflexes in 70 (29.5%), gross motor impairments in 235 (99.2%), fine motor impairments in 3 (1.3%), vision impairments in 6 (2.5%), hearing impairments in 6 (2.5%), speech impairments in 9 (3.8%), cognition impairments in 5 (2.1%), and seizures in 3 (1.3%).

The most common causes of impairments were respiratory distress syndrome (74%), sepsis (60%), delayed crying (44%), low birth weight (26.3%), intrauterine growth retardation (13.9%), and infant of diabetic mother (7%). The study population was predominantly urban (99.1%), with 0.8% classified as urban-rural and 0.1% as rural. All of the parents had a literacy rate of 100%.

The distribution of typically developed neonates and

those with impairments was observed, with the severity of impairments in different domains were graded as mild, moderate, or severe.

Among the impairments, the most common domains were found in mild gross motor impairments (6.1%), mild primitive reflexes (2.2%), and mild fine motor impairments (0.1%).

Table 1: Neonatal neurological examination (different domains).

Degree of risk based on response	Low or normal	Moderate risk	High risk
Primitive reflexes	Present	Weak	None
Gross motor	Present	Weak	None
Fine motor	Present	Weak	None
Vision	Present	Weak	None
Hearing	Present	Weak	None
Speech	Present	Weak	None
Cognition	Present	Weak	None
Behavior	Present	Weak	None

Table 2: Baseline characteristics of the neonates (n=2928).

Characteristics	N	%
Gender		
Male	1543	52.70
Female	1385	47.30
Place of newborn		
Nursery	2824	96.45
NICU	104	3.55
Residence		
Urban	2902	99.11
Urban-rural	23	0.79
Rural	3	0.10
Type of impairments		
Neurotypical	2691	91.91
Neuro-impairment	237	8.09
Probable cause of impairments		
Pre-term	539	18.41
Low birth weight	328	11.20
Intrauterine growth retardation	165	5.64
Infants of diabetic mothers	1341	45.80
Sepsis	123	4.20

Table 3: Domain wise severity grading in neonates with impairments (N=2928).

Name of domains	Typical neonates		Neonate with impairments		Mild impairments		Moderate impairments		Severe impairments	
	N	%	N	%	N	%	N	%	N	%
Primitive reflexes	2858	97.6	70	2.4	63	2.2	5	0.2	2	0.1
Gross motor	2693	92	235	8.02	178	6.1	50	1.7	7	0.2
Fine motor	2925	99.9	3	0.1	2	0.1	1	0	0	0
Vision	2922	99.8	6	0.2	6	0.2	0	0	0	0
Hearing	2922	99.8	6	0.2	6	0.2	0	0	0	0
Speech	2919	99.7	9	0.3	8	0.3	1	0	0	0
Cognition	2923	99.8	5	0.2	5	0.2	0	0	0	0
Behaviour	2928	100	0	0	0	0	0	0	0	0

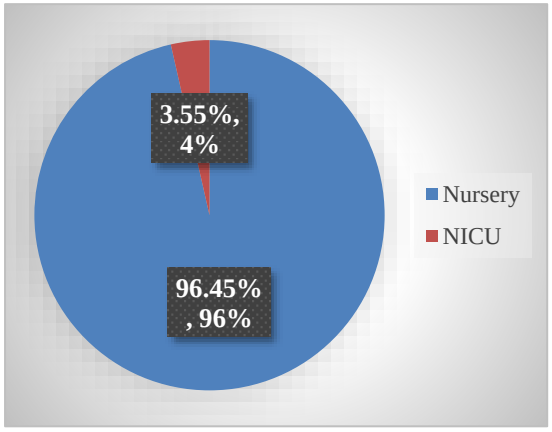

Figure 1: Proportion of neonates with neurological impairment came from nursery and NICU (N=237).

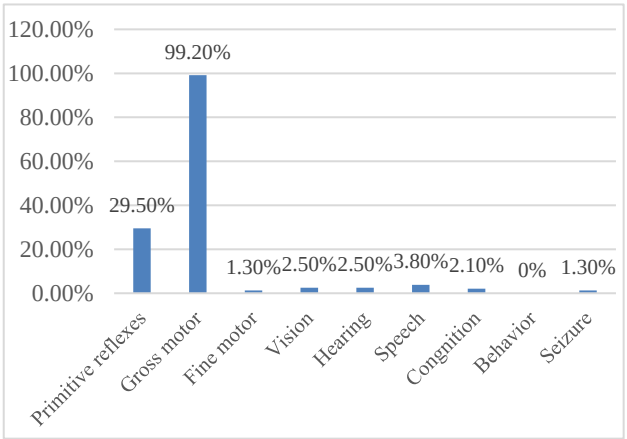

Figure 2: Domain wise neurological impairments (N=237).

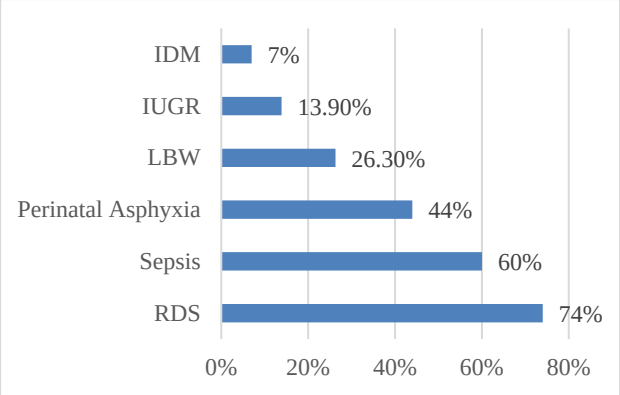

Figure 3: Proportion of different diseases among the neonate having impairments (N=237).

DISCUSSION

The aim of this study was to identify neurodevelopmental impairments in newborns and their possible risk factors, as well as to provide immediate management. To do so, we collected detailed medical histories which included antenatal, perinatal, and postnatal periods, paying special attention to family history for any familial risk factors. We also conducted a neurological assessment of the newborn using the neonatal rapid neurodevelopmental assessment (n-RNDA) tool, which is a reliable and valid neurodevelopmental assessment tool based on the International classification of function (ICF) by the WHO and is used for children aged 0-16 years.

The n-RNDA is particularly helpful for identifying children at high risk for neurodevelopmental impairments early on.[26] The n-RNDA assesses various domains in the neonate, including primitive reflexes, gross motor skills, fine motor skills, vision, hearing, speech, cognition, behavior, and seizures. Seizures are included even though they are not a functional domain but they are often associated as a functional co-morbidity. Different items are used to assess each domain, and impairments are graded as normal, mild, moderate, or severe based on the neonate's abilities. A score of 1 is assigned for normal development, 2 for mild impairments, 3 for moderate impairments, and 4 for severe impairments. At the end of the assessment, a summary sheet is used to describe the severity of the impairments in each domain by adding up the scores for the relevant items. The neonate is then categorized based on the severity of their neurodevelopmental impairments.[26]

This study included a total of 2928 neonates and assessment was done between 15 to 28 days of age to all neonates born in this hospital. It was found that there were 1542 male neonates (52.7%) and 1386 female neonates (47.3%), with more number of males being present in the study population. The majority of the neonates, 2924 (96.4%), came from the nursery, while the remaining 104 (3.55%) came from the neonatal intensive care unit (NICU). Of the total number of neonates, 237 (8.1%) had impairments, of which 63 (60.60%) coming from the NICU and 174 (6.16%) coming from the nursery.

This study revealed that neurodevelopmental impairments were more common in neonates came from the NICU, but 6.16% of neonates with impairments came from the nursery. This suggests that the n-RNDA should be used for all neonates, regardless of their risk category. Khan et al comments in their study that NDIs are common squeals of high-risk neonates. The most frequently affected domains were gross motor, fine motor and speech.[27] In this study, the major impairments by domain were found in gross motor (99.2%), speech (3.8%), vision (2.5%), hearing (2.5%), cognition (2.1%), and fine motor (1.3%). Costello et al have identified several common causes of neonatal neurodevelopmental impairments (NDIs), including severe asphyxia, intrauterine growth retardation, severe intraventricular hemorrhage (IVH), periventricular leukomalacia or infarction, meningitis, seizures, respiratory failure requiring mechanical ventilation, and poor growth (including head growth).[28] This aligns with the findings of this study, which showed that the causes of NDIs among the study population included delayed crying (44%), prematurity (18.40%), low birth weight (26.3%), intrauterine growth retardation (13.9%), being an infant of a diabetic mother (45.80%), sepsis (60%), and respiratory distress syndrome (74%), some of them needed ventilator supports.

According to the National data, 20% of infants are born prematurely in Bangladesh, and 30% have low birth weight (i.e., less than 2500 g). These risk factors can contribute to the development of neurodevelopmental impairments in newborns.[27] In this study, 18.4% of the newborns were preterm and 26.3% had low birth weight. Preterm birth is a known risk factor for neurodevelopmental impairments (NDIs), including delays in reaching developmental milestones, learning difficulties, and behavioral problems and the risk of major disability increases with decreasing gestational age. It is important for these children to receive timely and appropriate interventions to support their development and mitigate the potential long-term consequences of preterm birth.[28] This study has found a significant proportion of infants had impairments in more than one domain during the n-RNDA assessment. For example, some neonates had both gross motor and fine motor impairments, or gross motor and vision impairments, or impairments in multiple domains.

Many of these neonates also had overlapping causes of impairments, such as delayed crying/hypoxic-ischemic encephalopathy (PNA/HIE) with seizures, respiratory distress syndrome (RDS) with sepsis, and other combinations. These highlight the importance of early assessment in identifying developmental impairments in different domains and understanding the underlying causes. Follow-up assessments are also important in these cases to monitor the child's progress and to determine the need for further interventions. Other studies have found

that neonates born with various perinatal events are at risk for developmental impairments. Neurodevelopmental assessment in the early newborn period is a valuable tool for predicting outcomes[29] and requires a long term follow up plan with care.[30]

A study by Khan et al on 159 Bangladeshi preterm infants found that maternal education was a significant factor influencing the developmental outcomes of children. This study also observed that all the parents were educated and able to understand and follow instructions for managing their child, which had a positive impact on the newborn's health and development. Developmental therapy involves various forms of developmental stimulation, such as physical, cognitive, and visual stimulation, to promote growth and development. This type of early intervention is particularly beneficial for at-risk babies who are more susceptible to growth and developmental delays. Early intervention programs can help to mitigate the negative effects of these risks and support the child's overall development.[27,30]

Limitations

Several limitations exist in this study. Its single-hospital focus may restrict wider applicability to diverse populations, especially as it predominantly includes urban neonates. The reliance on immediate assessments limits insights into longer-term developmental trajectories.

CONCLUSION

Neonatal rapid neurodevelopmental assessment (n-RNDA) is a set of assessment tools used to evaluate the neurological function of newborns. The data collected from this study showed that neurological impairments were present in 8.1% of the neonates, majority of them came from NICU but a good number came from nursery too. It is highlighted on those so called normal neonates in nursery also have some sorts of impairments. So it rationalized that all neonates demand early neurological assessment with appropriate management. The n-RNDA screening program at Square Hospitals Ltd is the first of its kind in Bangladesh and provides access to early assessment and intervention for all neonates born in this hospital. The results of this program can be used to develop policies and guidelines for the institutionalization of n-RNDA as a tool for early diagnosis and successful outcomes of all neonates.

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