VOLUME - 13, ISSUE - 04, APRIL - 2024 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Radiodiagnosis

MRI BRAIN EVALUATION IN PATIENTS WITH DEVELOPMENTAL DELAY IN A TERTIARY CARE SETTING

Prajwaleet P. Gour	MD Radiodiagnosis, Department of Radiodiagnosis, Government medical college, Nagpur.
Nikhil Kumar Singh*	Junior Resident In Radiodiagnosis, Department of Radiodiagnosis, Government medical college, Nagpur. *Corresponding Author
Sonali Tiwari	MD Radiodiagnosis, Department of Radiodiagnosis, Government medical college, Nagpur.
Fathima Nashreen M.	Junior Resident In Radiodiagnosis, Department of Radiodiagnosis, Government medical college, Nagpur.

ABSTRACT

Introduction: Developmental delay is defined as when a child's progression through predictable developmental phases slows, stops, or reverses in any of the established developmental domains. Magnetic Resonance (MR) is the preferred modality to assess these patients and provides much better details than a plain or contrast CT. Evaluation of such patients is necessary not only for prognosticating the patient but also to identify any genetic association suggestive of as to provide effective guardian counseling. Thus this study was done to assess the array of imaging features in developmental delay in Indian children which will help the doctors to estimate the maximum development potential and cater specific individualized treatment. **Aims and Objectives:** To study the imaging morphology and its distribution in patients with developmental delay along with estimation of burden for different etiologies. **Materials And Methods:** It is a prospective, observational & descriptive study of MRI Brain in 73 patients (49 Males and 23 Females), aged between one month to 60 years; presenting with developmental delay in Government medical college and hospital, Nagpur; over a period of 18 months (July 2022 to January 2023). MRI brain was done on 3.0T Siemens Magnetom Vida with routine sequences like T1, T2, STIR, SWI, FLAIR, IR and DWI. All anatomical structures like gray-white matter, cerebellum, brainstem, ventricles etc. were systematically assessed. The MRI findings were divided into groups on the basis of etiology. **Results:** Normal MRI findings were seen in 23% cases and 77% had abnormal findings. Amongst the abnormal imaging features the attribution to hypoxic, congenital, metabolic, traumatic and infectious were 48%. 37%, 5% , 2% and 2% respectively. The anatomical structures to affected most commonly were found to be white matter and ventricles. **Conclusion:** Rather than considering the clinical diagnosis of developmental delay as the end-point of algorithm, MRI should be incorporated routinely in such patients to effective pin-point the pathology so as to cater personalized treatment and effective counseling.

KEYWORDS : Development, Delay, Growth, MRI, Hypoxia

INTRODUCTION:

Developmental delay is a multifaceted and challenging condition that significantly impacts a child's cognitive, motor, language and socio-emotional abilities. As a significant and grievous concern in pediatric health, identifying the underlying causes of developmental delay is important for timely intervention to help the patient reach their peak. Magnetic Resonance Imaging (MRI) has proved to be a powerful and invaluable diagnostic tool, providing detailed anatomical insights into the structure and function of the developing brain. This research paper aims to comprehensively evaluate and analyze the role of MRI imaging findings in the assessment of developmental delay.

Over the past decade, advances in neuro-imaging techniques have significantly improved our understanding of the complex processes involved in brain development. MRI, with its ability to capture high-resolution images of soft tissues and intricate neural structures, offers unparalleled dive into the neuroanatomical basis of developmental delay. By scrutinizing the subtle abnormalities and deviations from typical developmental trajectories, MRI contributes abundantly to the diagnostic process, guiding clinicians in catering personalized treatment plans.

This research endeavors to synthesize existing literature, incorporating recent studies and technological advancements, to assess MRI findings in the context of developmental delay. By depicting the relationships between specific brain abnormalities and developmental outcomes, we aim to enhance the diagnostic accuracy and prognostic value of MRI in guiding clinical decision-making

MATERIALS AND METHODS:

Study design

A prospective, observational & descriptive study of MRI of the Brain in 73 patients (49 Males and 24 Females) presenting with developmental delay in Government medical college and hospital, Nagpur; over a period of 18 months years (July 2022 to July 2023). Patients were categorized based on age group, sex, anatomical structures involved and etiology. The patients were further categorized into two groups based on the communication with the referring doctor as having developmental delay only and those with associated features such as epilepsy, neurological deficits, etc are termed as developmental delay plus.

Inclusion And Exclusion Criteria

All patients who were referred for brain MRI for evaluation of developmental delay, aged one month to 60 years, admitted for the first time to diagnose the cause of delay are included in the study. Patients with known Genetic Disorders such as Down syndrome, Turners Syndrome, deficiency disorders like rickets or protein energy malnutrition, Infections like pneumonia or any other communicable disease in active stage were excluded.

Sedation

For obtaining best quality images possible, it was required for the patient to remain still and motionless. Infants were generally examined unsedated & a very safe and simple "feed and scan" technique was used; in which the infants were fed and waited until they fell asleep, after which the scan was performed. In case the method did not work, the patient was taken under anesthesia.

While the other patients were either sedated by oral or IV drugs under the consent of the guardian or caretaker and presence of the pediatrician or sedated by using anesthetic drugs by the anesthetist in his presence. Consent of the parent and pediatrician were taken before the procedure. The children were generally given Triclofos Sodium orally of a dosage of 25 mg/kg body weight/dose or Syrup Chloral Hydrate with a dosage of 5 to 10mg /kg.

The following structures were systematically evaluated
o Size and morphology of ventricles
o Thickness and morphology of Corpus callosum
o Gray and white matter
o Basal ganglia
o Brainstem
o Cerebellum
o Non-specific: Any lesion not fitting in any of the above patterns of distribution

RESULTS

No significant MRI findings were seen in 23% (17 cases) of patients presenting with developmental delay. These children were advised further array of biochemical and genetic evaluation to diagnose the underlying cause of developmental delay. Abnormal anatomy was noted in the rest of the 77% (56 cases). Based on clinical history and details given by the patient, it was seen that only 39.7% patients presented with only developmental delay rest 60.3% presented with developmental delay along with additional features such as epilepsy, neurological deficits, microcephaly, facial dysmorphism, cleft lip/palate, visual and auditory disturbances, gait disturbances or motor disturbances. The patients with developmental delay associated with other features had higher yield of positive results [Table/Fig-2].

[Table/Fig-1]: Sex Distribution Of Study Population With Normal And Abnormal MRI

	Normal	Abnormal
Male	13	36
Female	4	20

[Table/Fig-2]: The Clinical Presentation Of Study Population With Normal And Abnormal MRI

	Normal	Abnormal
Developmental delay only	9	20
DD with other features	8	36

[Table/Fig-3]:

ETIOLOGY	
CONGENITAL	28
HYPOXIC	35
TRAUMATIC	2
METABOLIC	4
INFECTIOUS	2
NAD	17

[Table/Fig-4]:

ANATOMICAL INVOLVEMENT	
VENTRICLE	30
WHITE MATTER	45
CEREBELLUM	4
GRAY MATTER	3
BRAINSTEM	3
NON-SPECIFIC	12

The distribution of involved anatomical structures in patients with abnormal MRI (61 cases) was studied and presented in [Table 4]. Abnormalities of white matter took the lead forming around 45 cases with ventricular abnormality noted in 30 cases. The number of children with abnormal findings in cerebellum, gray matter and brainstem were 4, 3 and 3 respectively. Nonspecific abnormalities were found in 12 patients. Analysis of 73 cases based on the etiological factors showed normal MR features in 17 cases. 56 cases with abnormal MRI were further subgrouped; of which 35 cases had findings consistent with hypoxic etiology. The number of patients with congenital, hypoxic, traumatic, metabolic and infectious etiology is 28, 2, 4, and 2 respectively as shown in [Table 3].The most common abnormality encountered in present study Hypoxic Ischemic Encephalopathy (HIE) depicted in. Majority of these children belonged to one month to 24 months of age group. Around 67% of them were males and 33% were female. White matter, ventricles and corpus callosum were invariably affected in almost all hypoxia associated cases.

DISCUSSION

The presented data on the number of cases of developmental delay based on etiology as determined by MRI provides valuable insights into the diverse factors contributing to this complex condition. Understanding the underlying causes is crucial for formulating targeted interventions and improving outcomes for affected individuals.

1. Prevalence of Etiological Factors:

The data underscores the heterogeneous nature of developmental delay, with various etiological factors contributing to its occurrence. Congenital factors, such as genetic abnormalities and structural anomalies, constitute a substantial proportion of cases, as evidenced by the highest count in the CONGENITAL category. This aligns with existing literature emphasizing the significance of prenatal factors in developmental delay.

2. Perinatal Factors:

The HYPOXIC category reflects cases associated with perinatal factors, including oxygen deprivation during childbirth. This finding is consistent with the understanding that events surrounding the birth process can have a profound impact on neurodevelopment, highlighting the need for vigilant monitoring and timely interventions during labor and delivery.

3.Traumatic and Metabolic Contributions:

The relatively lower counts in the TRAUMATIC and METABOLIC categories suggest that trauma and metabolic disorders play a comparatively smaller role in developmental delay. However, even a limited number of cases in these categories merit careful consideration, as both traumatic events and metabolic imbalances can have severe consequences for the developing brain.

4. Infectious Etiology:

The INFECTIOUS category, while representing a small fraction, underscores the importance of recognizing and addressing infections as potential contributors to developmental delay. Infections can lead to inflammatory responses and neurologic complications, emphasizing the need for early identification and treatment.

5. Comparative Analysis – Normal vs. Abnormal MRI Findings:

The inclusion of a "Normal" category in the data provides a critical perspective. Seventeen cases with normal MRI findings suggest that developmental delay can exist in the absence of detectable structural abnormalities. This highlights the limitations of relying solely on anatomical assessments and underscores the need for a comprehensive, multi-modal approach to diagnosis.

6. Limitations and Future Directions:
It is crucial to acknowledge the limitations of this study, such as the relatively small sample size. Larger, multicenter studies are warranted to validate and extend these findings. Additionally, ongoing advancements in MRI technology may enhance our ability to detect subtle abnormalities, contributing to a more nuanced understanding of developmental delay etiology.

In conclusion, this discussion highlights the significance of the provided data in characterizing the etiological landscape of developmental delay based on MRI findings. The diverse nature of contributing factors emphasizes the need for a holistic and individualized approach to diagnosis and intervention, paving the way for improved outcomes for individuals affected by developmental delay.

The dataset on the prevalence of abnormal anatomy associated with developmental delay based on MRI findings offers critical insights into the specific regions of the brain implicated in this complex condition. Understanding the distribution of abnormalities across different brain structures is paramount for tailoring diagnostic assessments and interventions.

1. Prevalence of White Matter Abnormalities:
The notably high count in the WHITE MATTER category underscores the prominence of disruptions in white matter structures in cases of developmental delay. White matter plays a crucial role in facilitating communication between different regions of the brain, and abnormalities in this area may contribute significantly to the observed delays in cognitive and motor development.

2. Ventricular Abnormalities and Hydrocephalus:
The prevalence of abnormalities in the VENTRICLE category suggests a significant association with developmental delay. Ventricular abnormalities, including ventriculomegaly, may be indicative of increased cerebrospinal fluid (CSF) volume and potential hydrocephalus, emphasizing the importance of considering fluid dynamics in the diagnostic process.

3. Cerebellar Involvement and Motor Impairments:
The presence of abnormalities in the CEREBELLUM category highlights the potential impact on motor coordination and balance. The cerebellum is integral to motor learning and coordination, and abnormalities in this region may contribute to the observed developmental delays, particularly in fine and gross motor skills.

4.Gray Matter and Brainstem Involvement:
The lower counts in the GRAY MATTER and BRAINSTEM categories suggest that abnormalities in these regions are less prevalent in the studied cases. However, the importance of these structures in various cognitive and physiological functions cannot be understated. Further exploration of specific abnormalities in gray matter and brainstem may provide insights into additional contributing factors.

5. Non-Specific Abnormalities:
The "NON-SPECIFIC" category acknowledges the challenges in precisely categorizing certain anomalies, underscoring the complexity of anatomical abnormalities associated with developmental delay. These non-specific findings may include multifocal abnormalities or variations that do not neatly fit into predefined categories, requiring further investigation.

6. Clinical Implications and Intervention Strategies:
The distribution of abnormalities across different brain regions has direct implications for clinical practice. Tailoring interventions based on the specific anatomical findings becomes crucial for addressing the unique needs of each individual. Multidisciplinary collaboration among neurologists, radiologists, and developmental specialists is essential for comprehensive care.

7. Future Research and Technological Advancements:
While this study provides a snapshot of abnormalities associated with developmental delay, ongoing research should explore the underlying mechanisms and functional consequences of these anatomical variations. Additionally, advancements in imaging technology may refine our ability to detect subtle abnormalities and provide more detailed insights into the structural basis of developmental delay.

In conclusion, this discussion underscores the importance of anatomical considerations in understanding developmental delay based on MRI findings. The regional distribution of abnormalities informs both diagnostic strategies and intervention planning, ultimately contributing to a more nuanced and tailored approach to addressing developmental challenges in affected individuals.

CONCLUSION

In conclusion, the comprehensive analysis of the data presented today, encompassing both the etiology and abnormal anatomy of developmental delay based on MRI findings, provides a multifaceted understanding of this intricate and heterogeneous condition. The research underscores the interplay between causative factors and structural abnormalities, offering valuable insights for clinical diagnosis, intervention, and future research endeavors.

The distribution of cases based on etiology highlights the diverse factors contributing to developmental delay, with congenital, hypoxic, traumatic, metabolic, and infectious elements playing distinct roles. This diversity necessitates a nuanced and individualized approach to diagnosis and intervention, emphasizing the need for multidisciplinary collaboration among healthcare professionals.

Simultaneously, the examination of abnormal anatomy reveals specific regions of the brain implicated in developmental delay, with a noteworthy prevalence of white matter abnormalities, ventricular anomalies, and cerebellar involvement. These findings emphasize the critical importance of considering both the underlying cause and the specific anatomical abnormalities in guiding clinical decision-making.

The recognition of non-specific abnormalities and the acknowledgment of limitations in categorization underscore the complexity of developmental delay, prompting further research into the underlying mechanisms and potential functional consequences of these variations. Future investigations should also explore the dynamic nature of brain development and incorporate technological advancements to enhance our diagnostic capabilities.

Overall, this collective analysis contributes to the ongoing dialogue in the field of developmental neurology, paving the way for more targeted and effective approaches to the assessment and management of developmental delay. The integration of etiological and anatomical data promotes a holistic understanding of the condition, fostering a foundation for improved outcomes and quality of life for individuals affected by developmental delay.

REFERENCES

[1] Momen AA, Jelodar G, Dehdashti H. Brain Magnetic Resonance Imaging Findings in Developmentally Delayed Children. International Journal of Paediatrics. 2011 Article ID 386984
[2] Battaglia A, Carey JC. Diagnostic evaluation of developmental delay/mental retardation: An overview. American Journal of Medical Genetics Part C: Seminars in Medical Genetics. 2003;117(1):3–14.
[3] Shevell M, Ashwal S, Donley D, Flint J, Gingold M, Hirtz D, et al. Practice parameter: evaluation of the child with global developmental delay: report of

the quality standards subcommittee of the American Academy of Neurology and The Practice Committee of the Child Neurology Society. Neurology. 2003;60(3):367–80.
[4] McDonald LA, Rennie AC. Investigating developmental delay / impairment. Paediatrics and Child Health. 2011;21(10):443–47.
[5] Petersen MC, Kube DA, Palmer F B. Classification of developmental delays. Seminars in Pediatric Neurology. 1998;5(1):2–14.
[6] Pandey A, Phadke SR, Gupta N, Phadke RV. Neuroimaging in mental retardation. Indian J Pediatr. 2004;71(3):203–09.
[7] Koul R, Al-Yahmedy M, Al-Futaisi A. Evaluation children with global developmental delay: A prospective study at sultan qaboos university hospital, oman. Oman Medical Journal. 2012;27(4):310.
[8] Battaglia A, Bianchini E, Carey JC. Diagnostic yield of the comprehensive assessment of developmental delay/mental retardation in an institute of child neuropsychiatry. American Journal of Medical Genetics. 1999;82(1):60–66.
[9] Widjaja E, Nilsson D, Blaser S, Raybaud C. White matter abnormalities in children with idiopathic developmental delay. Acta Radiol. 2008;49(5):589–95.
[10] Sandeep P, Barkovich AJ. Analysis and Classification of Cerebellar Malformations. AJNR. 2002;23:1074–87.
[11] Williams HJ. Imaging the child with developmental delay. Imaging. 2004;16(2):174–85.
[12] Rivkin MJ. Developmental neuroimaging of children using magnetic resonance techniques. Ment Retard Dev Disabil Res Rev. 2000;6:68–80.