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Evaluation of the Developmental Delay in the Pediatric Patients by Magnetic Resonance Imaging (MRI)

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ABSTRACT

Milestones are the predicted points at which a child is expected to reach a certain developmental stage, like talking or walking. In the case when a child does not achieve a significant stage by the predicted age, it is known as a delayed milestone. Delayed milestones might have a variety of causes, including issues throughout pregnancy or delivery, genetic issues, and premature birth. Delays in milestones might result from issues that arise in infancy or early, like infections or head injuries. Frequently, no clear cause is found. This study aims to search in main causes that lead to increase developmental delay in pediatric and to confirm the MRI is superior modality that use to give true diagnosis. A prospective study was conducted on 65 individuals who had their developmental delay assessed using brain magnetic resonance imaging (MRI). The research was carried out at Children's Central Teaching Hospital and Medical City from August to October of 2022 G.C. In all, 65 patients have been included in the study; of these, 28 had 43.1% female patients and 37 had 56.9% male patients. A total of fifty individuals had abnormal brain MRI results, while fifteen patients had normal results. In children who have not reached their developmental milestones, MRI is a valuable investigative tool; in our study, a significant percentage of brain MRI abnormalities were found. Because of its ability to resolve soft tissues, MRI has frequently aided in the diagnosing process.

Introduction

Magnetic resonance imaging (MRI) is very sensitive to disease of the cerebral white matter and evaluate state of myelination both quantitatively and qualitatively, It’s the preferred method for approaching children with developmental delay [1].

Achieving adequate immobilization of the sometimes-uncooperative pediatric patients for the lengthy acquisition durations is crucial for any successful pediatric examination; hence, sedation is required. Commonly used techniques include monitoring conscious sedation, deep sedation, or general anesthesia. Children must refrain from eating or drinking anything for at least four hours before any sedation operation. It is essential to monitor critical functions, which can be done with ease by using a pulse oximeter [2].

Approximately 5% of children under the age of five experience developmental delay. Delays in the development of language and speech, motor skills, emotional and social skills, and cognitive abilities are all included in this. [3] A child's inability to accomplish specific tasks at a given period of life might be cause for concern and is commonly referred to as developmental delay. A notable delay in at least one of a child's developmental areas is referred to as developmental delay. [1] A developmental delay child's evaluation is crucial because it enables early diagnosis and treatment, supports parent counseling over the child's outcome, and helps in identifying any potential risk of recurrence. [4]

The first three years of a child's life are a time of rapid neuronal development in the brain. Any disruption to such process, like stress, trauma, malnutrition, or lack thereof, could have long-term impacts on the structure regarding the brain as well as the socioemotional development of the child. During this phase, a child's neurological and physical development happens quickly, and in order for them to realize their maximum potential in terms of academic success, quality of life, and earning potential, they need to eat a healthy diet. [5]

In the case when the brain is fully developed, the atrophied brain manifests with a reduction in parenchymal volume with the corresponding enlargement of sulcal spaces, basal cisterns, and ventricles, which are occupied by increased cerebrospinal fluid volume due to exvacuo response. Brain atrophy can be defined as an unusual reduction in brain volume that is not expected in the normal development and involution of the brain at a particular age. Although the process of brain volume decrease is frequently observed in the elderly, there are several indications that this observation can also be made in children. [6] Many factors, including infection, trauma and malnutrition, were linked to the loss of volume in the brain's tissues. [7]

Periventricular leukomalacia, or white matter lesions in prematurely born children, is a useful model for researching constraints on brain development. [8]

The most common type of brain injury and the main recognized cause of cerebral palsy and cognitive impairments in premature infants is periventricular leukomalacia (PVL). There is a growing number of low-birth-weight babies who live to show such neurologic abnormalities. Greater diagnostic sensitivity for PVL can be achieved with neuroimaging methods depending on MRI; in these cases, PVL is unmistakably a disease of both the white and gray matter. [8] A cleft filled with cerebrospinal fluid (CSF) that extends from the surface regarding the cerebral hemispheres to the ventricular surface (ependyma) is a characteristic of schizencephaly, a rare condition of neuronal migration. Abnormal neuronal migration in the initial weeks following gestation causes schizophrenia. [9]

The diagnosis of schizencephaly is confirmed via imaging. The full thickness cleft, is easily discernible in MRI images. MRI can be defined as the imaging modality of choice because of its ability to identify grey matter lining the cleft. [10]

An efficient way to diagnose brain disorders is with a traditional MRI with a contrast injection. [11]

It is advised to employ standard T1-weighted, T2-weighted, fluid-attenuated inversion recovery, and diffusion-weighted sequences when using magnetic resonance imaging (MRI) for brain examination. [12]

However, for some kinds of brain diseases, computed tomography is less sensitive than magnetic resonance imaging (MRI). [13]

The present study is to determine the main causes that lead to increase the developmental delay in the pediatric. To assess the efficiency of the MRI in determining true diagnosis of the delay milestones.

Patient and methods

A prospective study was conducted at the Central Teaching Hospital of Pediatric and Welfare Teaching Hospital. In this study, a total of sixty-five (65) patients were enrolled ((28) females, (37) males) with sign and symptoms of delayed milestone. The patient's age range was (2 months - 12 years).

Patients have been referred for magnetic resonance (MRI) examinations, during a period of two months starting from (1/8/2022) to (5/10/2022). MRI brain was done on 1.5T Siemens Magnetom Avanto.

Inclusion criteria

Pediatric patients (2 months - 12 years) years. Who need MRI scans to get good resolution and save whole life due to no use of ionizing radiation.

Exclusion criteria

1. Patients who have any metal in their body.
2. The patient is under sedation but is unstable in the exam and results in such low image quality that a full diagnosis is not made.

Method

All patients in this study were subjected to the following:

Patients history and health status: The following are some of the symptoms and signs that are associated with the delay milestone: slow learning and development compared to other children; difficulty remembering things; difficulty rolling over, crawling, sitting up, or walking much later than is developmentally appropriate; talking late or difficulty talking; difficulty socializing or communicating with others; difficulty remembering things in school; and difficulty doing daily tasks like dressing or using the restroom without assistance.

Magnetic resonance imaging methods:

Sedation

Patients must remain still for the best possible image quality that allows for an accurate diagnosis. The infants were evaluated without sedation using the safe and straightforward "feed and scan" method, which involves feeding the babies and waiting for them to fall asleep before doing the scan. The older children, on the other hand, were either put to sleep with anesthesia by the anesthetist in front of the pediatrician, or with oral or IV medication with his permission. Prior to the procedure, the pediatrician's and parent's consent were obtained. The patients were put to sleep in a supine position, and the head was wrapped in an air-exhausted bag to immobilize it.

Sedation material that uses for child:

1. Ketamine (1-2) mg/kg.
2. Medazolam (0.1) mg/kg.

The patient’s parents are advised that the child fast on the day of the examination in order to preserve the patient’s safety during anesthesia.

Magnetic resonance imaging technique

A few intriguing things happen to the hydrogen protons if the subject is placed in MRI scanner:

1. The magnetic field aligns them. There are two approaches to this: parallel and anti-parallel.
2. Because of the atom's magnetic momentum, they "wobble" or process along the z-axis, which is the direction of the external magnetic field.

Relaxation: The same would apply if the protons had elevated to a higher energy state and the net magnetization had rotated 90 degrees in the x-y plane. This happens as a result of the protons absorbing the RF pulse's energy. A relaxation period could be used to describe any relaxation process. T2 and T1 relaxation are the two phases that make up the relaxation process.

Table 1: Brain magnetic resonance imaging parameters

Parameter	Diffusion	T2w (flair)-transvers	T2W(blade)	T1W (sagittal)	T1W (transvers)
TR/TE	3700/114	4350/106	9000/94	550/8.7	550/8.7
Slice thickness	5mm	5mm	5mm	5mm	5mm
Field of view (mm) FOV	230 x 230	230 x 230	191 x 191	176 x 230	176 x 230

Matrix size	192p x 192	256 x 256	256 x 256	274 x 512	274 x 512s
Acquisition plane	Tra > Cor (-7.0)	Tra > Cor. (-5.9)	Tra > Cor. (-6.4)	sag	Tra > Cor (-4.6)

Where: TR: repetition time, TE: echo time, Tra: transverse, Cor: coronal, p: pixel, mm: millimeters, T1W: T1 weighted, T2W: T2 weighted, flair: fluid attenuated inversion recovery.

- FLAIR (Fluid Attenuated Inversion Recovery):
It is another variation in the IR (invers recovery) pulse sequence, usually this sequence is used to suppress the signal from cerebrospinal fluid (CSF) containing areas.

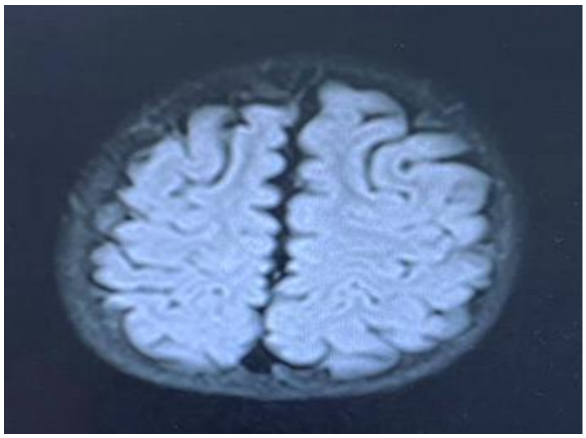

Figure 1: Fluid Attenuated Inversion Recovery (flair) image of brain MRI.

- Diffusion Weighted Imaging (DWI):
Provides contrast within the image which is different from that produced by traditional MRI methods, which rely on the motion of water molecules at a microscopic scale. Compared to conventional MRI measurements, like T2 or T1 relaxation rates, it is more sensitive to early changes of cytotoxic or vasogenic damage at the cellular level.
If the child patient moves during the exam, (flair-blade sequence) can help us by giving a better image of the other sequences by decrease the artifact in image that obtain from patient movement.

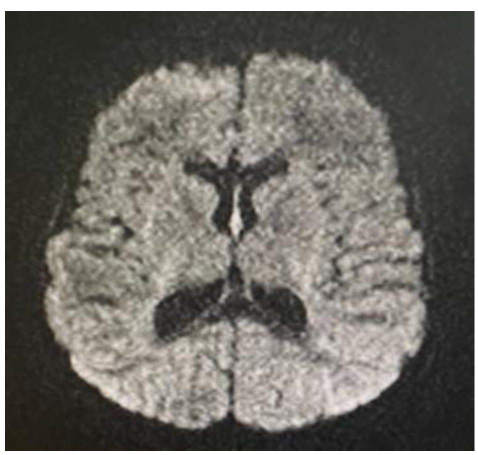

Figure 2: Diffusion weighted image (DWI) image of MRI brain.

Ethics

The study was conducted after getting approval from our institution's ethical committee and after consent from the patients.

Results and discussion

In our study, total 65 children were registered. Including 28 (43.1) were females and 37 (56.9) among them were males, maximum number were detected in age group of <2 years in 30 (46.2) of children followed by 2-5 years in 22 (33.8) of children, 6-10 years in 11 (16.9) of children and >10 years' age in 2 (3.1) of children.

Table 1: Distribution of patients according to their age group and gender

Variable	No.	(%)
Age		
<2Y	30	46.2
2-5Y	22	33.8
6-10Y	11	16.9
>10	2	3.1
Gender		
Female	28	43.1
Male	37	56.9
Total	65	100%

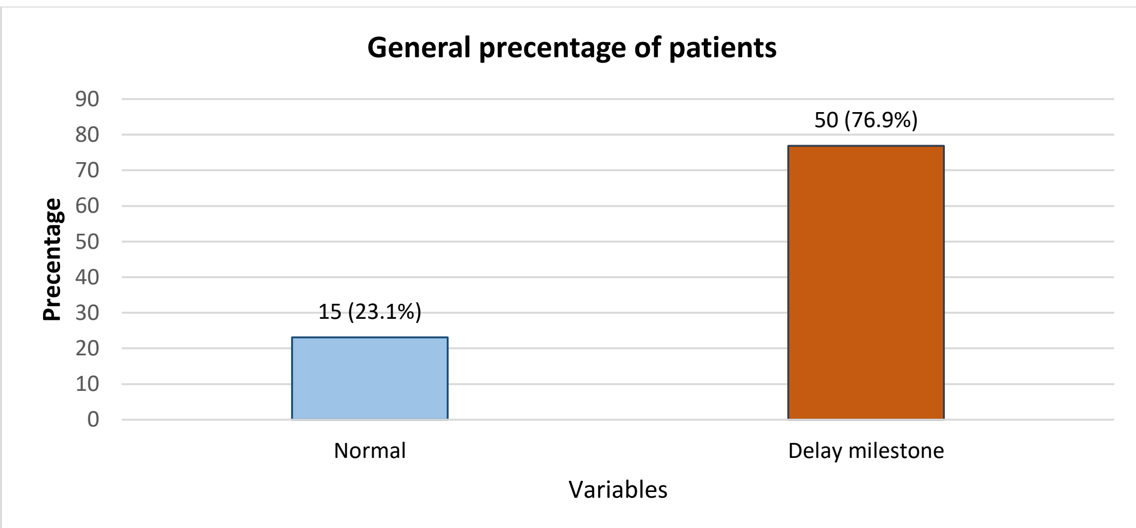

Figure 3: Distribution of cases according to the general percentage of patients.

As per the data of depicted above, 65 children that 15 (23.1) had normal and 50 (76.9) has abnormal.

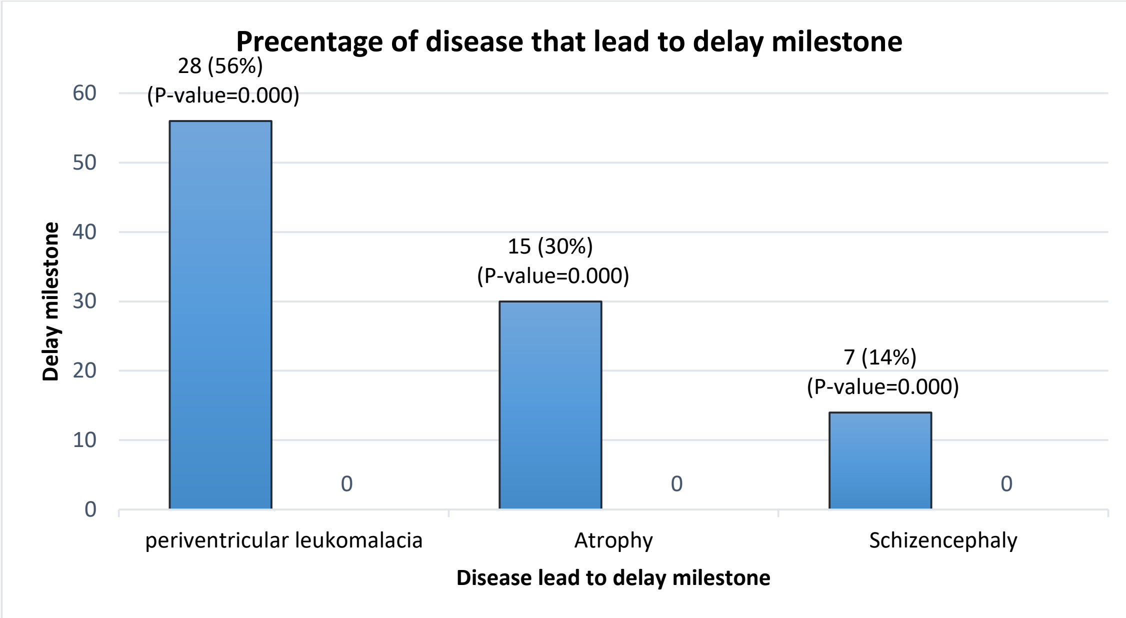

Figure 4: Distribution of patients according to diseases that lead to delay Milestones (DM).

As per the data of depicted above, show periventricular leukomalacia had higher prevalence at delay 28 (56%) followed by atrophy 15 (30%) and schizencephaly 7 (14%) disease that lead to delay milestone $p<0.001$ there was high significance association between disease and delay milestones.

Table 2: Distribution of patients according to the age, sex with normal and abnormal MRI.

Variable	n(%)		P-value
	Yes	No	
Age			0.603
<2Y	24 (80)	6 (20)	
2-5Y	17 (77.3)	5 (22.7)	
6-10Y	7 (63.6)	4 (36.6)	
>10	2 (100)	0 (0)	
Gender			0.385
Male	27 (73)	10 (27)	
Female	23 (82.1)	5 (17.9)	

According to the statistics above, patients older than 10 years had a higher prevalence of delay (100%) compared to patients younger than 2 years (80%), older than 5 years (77.3%), and older than 10 years (63.6%). Data shows that there was no statistically significant relationship between age groups and delay (p= (0.603)). The table indicates that there was no significant correlation between delay and age; male sex was higher at 27 (73%) compared to female sex at 23 (82.1) (p-value = 0.385).

Table 3: Mode and hypoxic insult distribution of study population with abnormal and normal MRI.

Variable	n(%)		P-value
	Yes	No	
Mode			0.164
Vaginal	40 (76.9)	12 (23.1)	
Caesarean	10 (83.3)	2 (16.7)	
hypoxic insult			

Perinatal			
Yes	35 (100)	0 (0.0)	0.000
No	15 (50)	15 (50)	
Natal			
Yes	41 (100)	0 (0.0)	0.000
No	9 (37.5)	15 (62.5)	
Postnatal			
Yes	39 (100)	0 (0.0)	0.000
No	11 (42.3)	15 (57.7)	

As per the data of depicted above, show that vaginal mode had prevalence 40 (76.9) followed by caesarean 10 (83.3), p=0.164 no significant association between mode of delivery and delay and show that natal hypoxic patient had higher prevalence 41 (100%), but there are 9 (37.5) haven't natal but they have a delay in growth, followed by postnatal 39(100) but there are 11(42.3) haven't postnatal but they have a delay in growth and perenatal 35((100) but 15 (50) haven't perinatal but they have a delay in growth, p<(0.001) there has been high significant association between hypoxic insult and delay.

Table 4: Distribution of cases based on the MRI findings-structural morphology.

Variable	n(%)		P-value
	Yes	**No**	
Ventricles			
Yes	32 (100)	0 (0.0)	0.000
No	18 (54.5)	15 (45.5)	
Corpus callosum			
Yes	22 (100)	0 (0.0)	0.002
No	28 (65.1)	15 (34.9)	
Brainstem			
Yes	13 (100)	0 (0.0)	0.027
No	37 (71.2)	15 (28.8)	
Cerebellum			
Yes	13 (100)	0 (0.0)	0.027
No	37 (71.2)	15 (28.8)	
White matter			
Yes	49 (100)	0 (0.0)	0.000
No	1 (6.3)	15 (93.8)	
Gray matter			
Yes	20 (100)	0 (0.0)	0.003
No	30 (66.7)	15 (33.3)	

As per the data of depicted above, show abnormalities of ventricle and white matter mainly the most common found that white matter 49 (100) and ventricles 32 (100) were the most commonly involved structures and followed by corpus callosum 22 (100), gray matter 20 (100), brainstem 13 (100), cerebellum 13 (100), there are patients who do not have it, but they do have delay in growth' p-value for ventricle and white matter was <(0.001) there was high significant association between them and delay, p-value for corpus callosum (0.002), brainstem (0.027), cerebellum (0.027), gray matter (0.003) there was significant association between them and delay.

The 65 cases are classified into fourth age group the prevalence of developmental delay was significantly higher among <10 children as compared to other age groups there is no relation between abnormal MRI finding and age group its agree with. [14], [15]
The classification of 65 patients according to the gender was females (43.1%) and males (56.9%) there is no relation between gender and prevalence of developmental delay this coincide with previous study. [16], [17]
There is three causes lead to developmental delay the prevalence of disease increases when it done in presence of specific problems (Periventricular leukomalacia, atrophy and Schizencephaly the p-value indicate that strong association between them this agree with study. [18], [19] These studies show that patients who have one or more of these causes it is have high significantly for delayed. [20]

Conclusion
The diagnosis of developmental delay etiologies is aided by brain MRI assessment. The developmental delay's clinical diagnosis shouldn't be the sole outcome. The best test with the highest yield in these patients with developmental delays is MRI.

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