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Original Research Article

JUVENILE STROKE: INSIGHTS FROM RADIOLOGICAL IMAGING

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ABSTRACT

Background: Stroke, a condition characterized by the sudden disruption of blood flow to the brain, is commonly associated with aging populations. **Objective:** The main objective of the study is to find the juvenile stroke and its insights from radiological imaging.
Materials and Methods: This study was conducted at Dept of Radiology, Saraswati Institute of Medical College Hapur UP, India during Nov 2023 to April 2024. A total of 55 patients were included in the study. Patients age <18 years of age, have a clinically confirmed stroke, and present radiological evidence of either ischemic or hemorrhagic stroke were included in the study. Patients with transient ischemic attacks (TIA) that lacked radiological confirmation or those with incomplete medical or imaging records were excluded.
Results: The study included 55 patients, comprising 30 males (54.5%) and 25 females (45.5%). The average age of the patients was 12.4 years (range: 3–17 years). Ischemic stroke was the most common type, accounting for 70.9% (39/55) of cases, while hemorrhagic stroke constituted 29.1% (16/55). Among the clinical presentations, the most frequent symptoms were sudden weakness or hemiparesis (60%), followed by severe headache (25%), seizures (20%), and altered consciousness (15%).
Conclusion: It is concluded that radiological imaging plays a pivotal role in the diagnosis, management, and follow-up of juvenile stroke, offering precise insights into stroke types and underlying etiologies. Advanced modalities like MRI, DWI, SWI, and MRA significantly enhance diagnostic accuracy and guide targeted interventions.
Keywords: Juvenile Stroke, Radiological imaging.

INTRODUCTION

Stroke, a condition characterized by the sudden disruption of blood flow to the brain, is commonly associated with aging populations. However, strokes in the pediatric and adolescent age groups, collectively referred to as juvenile stroke, represent an important and under-recognized subset of cerebrovascular diseases.[1]Juvenile stroke, defined as any stroke occurring before the age of 18, carries unique challenges in diagnosis, treatment, and long-term management. Although relatively rare, with an estimated annual incidence of 1 to 6 per 100,000 children, the burden it imposes on individuals, families, and healthcare systems is profound. Unlike adult stroke, which predominantly stems from modifiable risk factors such as hypertension, diabetes, and lifestyle choices, juvenile stroke is frequently associated with congenital, genetic, or systemic causes that require a tailored approach for diagnosis and management.[2]Radiological imaging has emerged as an indispensable tool in the evaluation and management of juvenile stroke. Advanced imaging modalities not only provide clarity on the immediate effects of cerebrovascular accidents but also offer valuable insights into the underlying etiologies, which can differ significantly from those observed in adults. For example, conditions such as congenital heart disease, sickle cell anemia, moyamoya disease, and inherited thrombophilias are more commonly implicated in juvenile stroke than in adult cases. Identifying these root causes through radiological imaging is vital for timely and targeted interventions.[3]Initial diagnosis of stroke in children often begins with non-contrast computed tomography (CT), which can rapidly identify life-threatening conditions such as hemorrhagic stroke. However, magnetic resonance imaging (MRI) is increasingly favored as the first-line modality due to its superior sensitivity in detecting acute ischemia and its ability to provide detailed information about brain tissue, blood vessels, and surrounding structures. Diffusion-weighted imaging (DWI) is particularly valuable for identifying areas of restricted diffusion that signify acute infarction.[4] Furthermore, MR angiography (MRA) and CT angiography (CTA) can assess vascular abnormalities, such as stenosis, aneurysms, or emboli, which are critical in determining the cause of the stroke.Juvenile stroke often results from complex and multifactorial causes, necessitating detailed imaging to uncover the underlying etiology.[5] Imaging modalities such as conventional angiography, MRA, or CTA help identify vascular pathologies, including moyamoya disease or arteriovenous malformations. Additionally, MRI with specific sequences, such as susceptibility-weighted imaging (SWI), can detect microhemorrhages or iron deposition associated with venous thrombotic events. In cases involving systemic diseases such as sickle cell anemia, transcranial Doppler (TCD) ultrasound is frequently employed to assess cerebral blood flow velocity and identify children at risk for stroke.[6]

Once the diagnosis and cause are established, radiological imaging guides treatment decisions, such as anticoagulation for thrombotic strokes or surgical interventions for vascular anomalies. Imaging also aids in evaluating the effectiveness of therapies over time. For example, follow-up MRIs can assess the extent of tissue recovery or secondary injury, while MRA or CTA can monitor vascular patency after interventions.Despite the critical role of radiology, juvenile stroke presents unique challenges in imaging evaluation.[7] First, children may require sedation for lengthy MRI procedures, posing logistical and safety concerns. Second, interpreting imaging findings in young brains requires expertise to differentiate between normal developmental variations and pathological changes. Additionally, certain conditions, such as autoimmune vasculitis or metabolic disorders, may present with subtle or atypical imaging features, necessitating advanced techniques like functional MRI or spectroscopy for accurate diagnosis.[8]The field of radiological imaging continues to evolve, offering new possibilities for understanding and managing juvenile stroke. Functional imaging, such as perfusion MRI and positron emission tomography (PET), is increasingly used to assess cerebral perfusion and metabolic activity.[9]Artificial intelligence and machine learning algorithms are also being integrated into imaging workflows, enabling faster and more accurate interpretation of complex data. These advancements hold promise for improving outcomes in juvenile stroke by facilitating earlier detection, personalized treatments, and precise monitoring.[10]

Objective

The main objective of the study is to find the juvenile stroke and its insights from radiological imaging.

MATERIALS AND METHODS

This study was conducted at This study was conducted at Dept of Radiology, Saraswati Institute of Medical College Hapur UP, India during Nov 2023 to April 2024. A total of 55 patients were included in the study. Patients age <18 years of age, have a clinically confirmed stroke, and present radiological evidence of either ischemic or hemorrhagic stroke were included in the study. Patients with transient ischemic attacks (TIA) that lacked radiological confirmation or those with incomplete medical or imaging records were excluded. All patients underwent a comprehensive radiological evaluation as part of their diagnostic workup. Initial imaging included non-contrast computed tomography (CT), which was utilized to identify acute hemorrhages and detect large infarctions. Magnetic resonance imaging (MRI) was subsequently performed, incorporating diffusion-weighted imaging (DWI), T1-weighted, T2-weighted, and fluid-attenuated inversion recovery (FLAIR) sequences to confirm ischemic events and assess brain tissue changes. Magnetic resonance angiography (MRA) was employed to evaluate cerebral vasculature for abnormalities, such as stenosis, aneurysms, or occlusions, while susceptibility-weighted imaging (SWI) was used to detect microbleeds or venous thrombosis. In cases of underlying conditions like sickle cell anemia, transcranial Doppler (TCD) ultrasound was used to assess cerebral blood flow velocities and identify patients at risk of stroke. These imaging techniques provided a comprehensive overview of each patient’s condition and were integral to the study.

Data Collection

Patient data were collected from medical records and radiological reports, ensuring that both clinical and imaging findings were included. Demographic information, clinical presentation details, and data on underlying conditions, such as congenital heart disease, sickle cell anemia, or thrombophiliawere recorded to establish correlations with radiological findings. This robust data collection process ensured that the study could analyze the relationships between clinical factors and imaging outcomes comprehensively.

Statistical Analysis

Data were analyzed using SPSS v29. Descriptive statistics, including mean and standard deviation, were used for continuous variables, while categorical variables were analyzed using percentages and proportions.

RESULTS

The study included 55 patients, comprising 30 males (54.5%) and 25 females (45.5%). The average age of the patients was 12.4 years (range: 3–17 years). Ischemic stroke was the most common type, accounting for 70.9% (39/55) of cases, while hemorrhagic stroke constituted 29.1% (16/55). Among the clinical presentations, the most frequent symptoms were sudden weakness or hemiparesis (60%), followed by severe headache (25%), seizures (20%), and altered consciousness (15%). [Table 1]

Non-contrast CT successfully identified acute hemorrhage in 15 of the 16 hemorrhagic stroke cases, demonstrating a sensitivity of 93.8%. However, it was less effective in detecting ischemic stroke, with only 12 of the 39 ischemic cases showing clear infarction signs, resulting in a sensitivity of 30.8%. [Table 2]

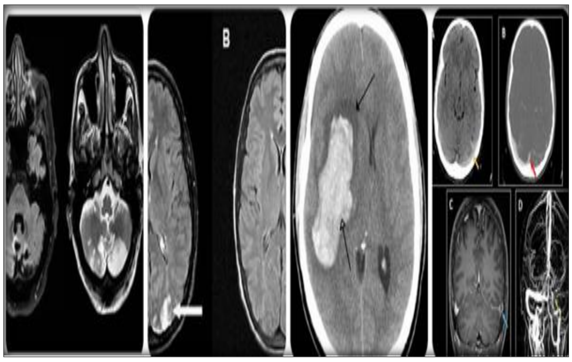

Figure 1: This image depicts hyperintense areas in the occipital lobes, indicative of ischemic infarctions. Such findings are crucial for identifying the affected brain regions and planning appropriate interventions.MRI confirmed ischemic stroke in 38 out of 39 cases, with a sensitivity of 97.4%. Diffusion-weighted imaging (DWI) was particularly effective in detecting acute ischemic lesions, identifying restricted diffusion in all 39 ischemic cases (100%). In addition, MRI provided valuable information on tissue damage, with FLAIR sequences highlighting chronic infarcts in 10% of cases. Hemorrhagic strokes were accurately diagnosed in 100% of cases using susceptibility-weighted imaging (SWI), which also identified microbleeds in 7 patients (12.7%).The most common underlying condition identified was congenital heart disease, found in 20% (11/55) of the patients, followed by sickle cell anemia (14.5%, 8/55), moyamoya disease (10.9%, 6/55), and inherited thrombophilia (9.1%, 5/55). Other contributing factors included trauma, vasculitis, and infections, which together accounted for 12.7% of cases. No identifiable cause was found in 16.4% (9/55) of patients, classified as cryptogenic strokes.

Radiological imaging significantly influenced treatment decisions in 85% of cases. For example, anticoagulation therapy was initiated in 12 patients (30.8% of ischemic cases) based on imaging findings of thromboembolism, while 3 patients with moyamoya disease underwent surgical revascularization. Follow-up imaging in 40 patients revealed partial or full recovery in 65% of ischemic cases and stable outcomes in 80% of hemorrhagic cases. [Table 3]

Table 1:Patient Demographics and Clinical Presentation

Variable	Number of Patients (N=55)	Percentage (%)
Gender		
Male	30	54.5
Female	25	45.5
Age (Years)		
Mean Age	12.4	-
Range	3–17	-
Stroke Type		
Ischemic Stroke	39	70.9
Hemorrhagic Stroke	16	29.1
Presenting Symptoms		
Weakness/Hemiparesis	33	60.0
Severe Headache	14	25.5
Seizures	11	20.0
Altered Consciousness	8	15.0

Table 2: Imaging Findings

Imaging Modality	Parameter	Findings	Sensitivity (%)
Computed Tomography (CT)	Acute Hemorrhage Detection	15/16	93.8
	Ischemic Stroke Detection	12/39	30.8
Magnetic Resonance Imaging (MRI)	Ischemic Stroke Detection	38/39	97.4
	Acute Lesion Detection (DWI)	39/39	100.0
	Hemorrhage Detection (SWI)	16/16	100.0
Magnetic Resonance Angiography (MRA)	Vascular Abnormalities	28/55	-
Transcranial Doppler (TCD)	Elevated Blood Flow Velocities	10/12	83.3

Table 3: Etiological Insights

Etiology	Number of Patients (N=55)	Percentage (%)
Congenital Heart Disease	11	20.0
Sickle Cell Anemia	8	14.5
Moyamoya Disease	6	10.9
Inherited Thrombophilia	5	9.1
Trauma	4	7.3
Vasculitis	3	5.5
Infections	3	5.5
Cryptogenic (Unknown Cause)	9	16.4

Table 4: Treatment Implications and Outcomes

Parameter	Number of Patients	Percentage (%)
Treatment Decisions Based on Imaging		
Anticoagulation Therapy	12 (Ischemic Cases)	30.8 (of ischemic)
Surgical Revascularization	3 (Moyamoya Cases)	5.5
Follow-Up Outcomes		
Partial/Full Recovery (Ischemic Stroke)	25/39	65.0
Stable Outcome (Hemorrhagic Stroke)	13/16	80.0

DISCUSSION

Juvenile stroke is a multifaceted condition that poses significant challenges in diagnosis, treatment, and long-term management. Unlike adult stroke, which is often linked to modifiable risk factors, juvenile stroke is frequently associated with congenital, genetic, and systemic conditions, requiring specialized diagnostic approaches. Radiological imaging has proven to be an invaluable tool in addressing these challenges, offering precise and timely insights into the underlying causes, types of stroke, and the extent of brain damage.[11]The results of this study emphasize the critical role of advanced imaging modalities in juvenile stroke management. Magnetic resonance imaging (MRI) was shown to be highly effective, with diffusion-weighted imaging (DWI) achieving a 100% sensitivity rate for detecting acute ischemic lesions. This underscores the importance of MRI as the gold standard for ischemic stroke diagnosis in pediatric populations.[12]Similarly, susceptibility-weighted imaging (SWI) demonstrated excellent sensitivity in identifying hemorrhagic strokes and microbleeds, making it an essential component of comprehensive stroke evaluation. These findings align with existing literature, highlighting MRI's unparalleled ability to differentiate between stroke types and provide detailed anatomical and pathological information.[13] Magnetic resonance angiography (MRA) and transcranial Doppler (TCD) ultrasound also played pivotal roles in identifying underlying vascular abnormalities, such as moyamoya disease and increased cerebral blood flow velocities associated with sickle cell anemia.[14]These findings are crucial for guiding targeted interventions, such as surgical revascularization in moyamoya disease or initiating prophylactic treatments in patients with sickle cell anemia to reduce stroke risk.The study revealed that congenital heart disease, sickle cell anemia, and moyamoya disease were among the most common underlying conditions associated with juvenile stroke.[15] These findings highlight the importance of thorough clinical and radiological evaluations to identify these risk factors, which differ significantly from those in adult stroke populations. However, 16.4% of cases remained cryptogenic, underscoring the limitations of current diagnostic tools in uncovering all potential etiologies.[16]This highlights the need for continued advancements in imaging techniques and the integration of genetic and metabolic testing to enhance diagnostic accuracy.Radiological imaging directly influenced treatment decisions in 85% of cases, demonstrating its crucial role in clinical management. For instance, anticoagulation therapy was initiated in patients with thromboembolic strokes, while surgical revascularization was performed in selected cases of moyamoya disease. The ability of imaging to guide such interventions is critical for improving outcomes in juvenile stroke patients.[17]Moreover, follow-up imaging revealed that 65% of ischemic stroke patients achieved partial or full recovery, indicating that timely and accurate imaging can significantly impact recovery trajectories.Despite its advantages, imaging in juvenile stroke has limitations. The need for sedation during MRI in young children poses logistical and safety challenges, potentially delaying diagnosis.[18] Additionally, the interpretation of pediatric imaging requires expertise to distinguish between normal developmental changes and pathological findings. Emerging technologies, such as functional imaging and artificial intelligence (AI)-based tools, hold promise in overcoming these limitations. For example, AI can assist in analyzing large datasets, improving the detection of subtle abnormalities, and predicting outcomes.

CONCLUSION

It is concluded that radiological imaging plays a pivotal role in the diagnosis, management, and follow-up of juvenile stroke, offering precise insights into stroke types and underlying etiologies. Advanced modalities like MRI, DWI, SWI, and MRA significantly enhance diagnostic accuracy and guide targeted interventions. Continued advancements in imaging technologies and integrated approaches are essential for improving outcomes and quality of life for young stroke patients.

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