ORIGINAL ARTICLE

Comparative Outcomes of Paediatric Stroke in Supratentorial and Infratentorial Regions: A 12-Year Hospital-Based Study

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ABSTRACT

Objectives: The clinical outcomes of pediatric stroke in patients can vary significantly depending on the affected brain region. Supratentorial and infratentorial strokes may present different clinical features and prognoses. Understanding these differences is crucial for developing targeted treatment strategies and improving patient care. Accordingly, this study aimed to compare the outcomes of patients under 18 years old with supratentorial and infratentorial strokes.

Materials & Methods: This retrospective cohort study included 100 children under 18 years old hospitalized due to stroke at Ali Asghar and Rasoul Akram hospitals from 2011 to 2023 and followed for 24 months. The motor and cognitive impairments were assessed 24 months post-stroke using the Modified Rankin Scale (MRS), the Bayley-III Scale (for children under three years), and the Binet scale (for children over three years). Statistical analyses were performed using T-tests and Chi-square tests. The required data include age, gender, stroke type (ischemic or hemorrhagic), stroke location (supratentorial /infratentorial), and underlying conditions.

Results: The mean age of the patients was 70.47 months. About 57% of the patients were older than two years, and 67% were male. Supratentorial stroke was observed in 78% of cases. No significant difference was observed in age or gender distribution between the supratentorial and infratentorial groups (P = 0.64 and P = 0.128, respectively). Outcome comparisons between the groups revealed no significant difference in Binet scores; however, children with supratentorial strokes had significantly lower Bayley scores and higher MRS scores compared to the infratentorial group (P = 0.023 and P = 0.002, respectively).

Conclusion: The present findings indicate that children with supratentorial strokes may experience more severe long-term motor and cognitive impairments. Further research is needed to investigate long-term outcomes in pediatric stroke patients based on stroke location.

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Introduction

Stroke is defined as a neurological disorder resulting from a sudden focal injury to the central nervous system (CNS) due to vascular causes, including arterial ischemic stroke (AIS) and intracerebral hemorrhage (ICH) (1). The estimated incidence of stroke in children aged 29 days to 18 years is 1.72 per 100,000 per year, while in neonates from birth to 28 days, it is 10.2 per 100,000 live births. Although pediatric stroke is relatively rare, it remains one of the top ten causes of mortality in children (2, 3), with reported mortality rates ranging from 10% to 25% (4).

Neurological impairments resulting from childhood stroke are associated with long-term disability and a reduced quality of life. Research indicates that most children who experience stroke develop persistent neurological, motor (e.g., hemiparesis), cognitive, social, learning, speech, swallowing, and cranial nerve impairments, as well as epilepsy, all of which can

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significantly impact daily functioning (2,5,6). The outcomes of pediatric stroke can vary depending on factors such as age at the time of injury, mechanism of injury, lesion size, and stroke location (7). From a neuroanatomical perspective, supratentorial strokes occur above the tentorium cerebelli, while infratentorial strokes affect structures below this membrane, including the brainstem and cerebellum. Limited studies have examined the impact of stroke location on pediatric patient outcomes. For example, Yong et al.'s study reported that patients with infratentorial strokes experienced greater swallowing difficulties than those with supratentorial strokes (8). Given the potential impact of stroke location on clinical outcomes, understanding these differences is crucial for optimizing management strategies and improving patient care. This study has two main goals. First, it aims to deliver a detailed report on pediatric stroke patients under the age of 18. This includes evaluating the extent of motor dysfunction, such as hemiparesis and other movement disorders, as well as the prevalence of cognitive and psychological impairments like learning difficulties, memory issues, and emotional disturbances. Additionally, the study will determine the overall mortality and recovery rates of these patients over time. The second goal is to compare the outcomes of supratentorial and infratentorial strokes in pediatric patients under 18. This comparison is intended to identify stroke-related risk factors and clinical consequences.

By recognizing the long-term consequences and risk factors of pediatric stroke, the present study aims to contribute to developing more effective therapeutic approaches and preventive measures for pediatric patients, ultimately improving patient care and outcomes.

Neurological impairments resulting from pediatric stroke are associated with long-term disability and a diminished quality of life. Research indicates that most children who experience stroke develop persistent neurological, motor (e.g., hemiparesis), and cognitive impairments, leading to significant challenges in daily functioning. The outcomes of pediatric stroke can vary based on multiple factors, including age at the time of injury, mechanism of injury, lesion size, and stroke location.

Materials & Methods

This is a multicentre retrospective cohort study of pediatric patients under 18 years diagnosed with supratentorial or infratentorial stroke admitted to Ali Asghar and Rasoul Akram Hospitals from 2011 to 2023. Data was collected from patient records using pre-structured checklists. This included demographic details like age (in years) and gender, as well as clinical variables. The stroke characteristics were documented, specifying stroke location (supratentorial or infratentorial) based on Magnetic Resonance Imaging (MRI) findings, and stroke type (ischemic or hemorrhagic) as determined by a neurology specialist.

Functional outcomes include several key areas:

Motor Impairment: This is evaluated using the Modified Rankin Scale (MRS) at 24 months after a stroke to determine the level of physical disability.

- **Cognitive Impairment:** Assessed through the Bayley-III and Binet Scales, this measures the impact on mental functions.
- **Recovery:** Defined as the absence of any lingering motor, cognitive, or psychological deficits at the 24-month follow-up. This is confirmed through MRI scans and clinical evaluations.
- **Mortality:** This refers to the death rate within the study group over the 24-month period.

These outcomes help in understanding the long-term effects after a stroke.

Study population

The study targeted all children under 18 years diagnosed with stroke and admitted to the aforementioned hospitals between 2011 and 2023. All eligible patients who met the inclusion criteria, children under 18 years old diagnosed with stroke, admitted to Hazrat Ali Asghar and Hazrat Rasoul-e-Akram hospitals between 2011 and 2023. Complete hospital records and correctly filled-out study questionnaires were obtained from participants enrolled in the study through a census sampling method.

Exclusion criteria were characterised as age over 18 years, refusal to participate, incomplete medical records, migration out of the country, death during the study, and congenital stroke.

The Ethics Committee of Iran University of Medical Sciences (IR.IUMS.FMD.REC.1403.313) approved this study. Furthermore, the Helsinki Declaration was respected throughout the study. Informed consent was obtained from parents and children over 13 years old before participation. Besides, parents were given ample time to review and ask questions before signing the consent form. Participants underwent tests (Bayley, Binet, and MRS) at Ali Asghar and Rasoul Akram hospitals with no additional costs. All data were kept confidential, and parents were informed that participation would not affect their child's regular treatment.

Description of assessment tools

1. Motor dysfunction evaluation:

The MRS was used to assess motor dysfunction. This scale rates disability from zero (no symptoms) to

6 (death). Patients with a score higher than 0 were considered to have motor dysfunction.
2. Cognitive and behavioural dysfunction evaluation:

Bayley-III Scale for children under three years old, assessing cognitive, motor, and social-emotional development.

3. The SB5 Scale for children over three years old to assess cognitive development and intellectual abilities.
4. Stanford-Binet Intelligence Scale (Fifth Edition) was used to evaluate IQ levels.

The MRS, Bayley-III, and SB5 scales were administered according to age and clinical criteria. Follow-up data were collected for 24 months to assess outcomes, such as mortality, motor dysfunction, cognitive impairment, and recovery. The MRS, Bayley-III, SB5, and IQ scales assessed cognitive and motor impairments. Recovery was defined as the absence of cognitive or motor impairments.

Statistical analysis

Descriptive and inferential statistical methods were applied using SPSS software. Data normality was tested using the Kolmogorov-Smirnov test. For normally distributed data, means and standard deviations were reported, and t-tests were used for comparisons. Non-normal data were analysed using the Mann-Whitney U test. Correlations were calculated using Pearson or Spearman's correlation tests, depending on data distribution. Fisher's Exact Test was used for categorical data comparisons.

Review of international studies on pediatric stroke

Felling et al. investigated predictors of recovery and outcomes following pediatric AIS, hypothesizing that age influences post-stroke recovery. The study included children enrolled in the International Pediatric Stroke Study between 2003 and 2014. Regardless of recurrence, outcomes were assessed at discharge and during a two-year follow-up. At discharge, the severity of neurological deficits was classified as normal, mild, moderate, or severe based on clinical examinations. The Pediatric Stroke Outcome Measure (PSOM) was utilized for long-term follow-up.

Five hundred eighty-seven patients were included, comprising 174 neonates and 413 children. Moderate-to-severe neurological impairments were observed in 9.4% of neonates and 48.8% of children at discharge, improved to 8.0% and 24.7%, respectively, at the two-year follow-up. Predictors of poor outcomes included age between 28 days and one year, chronic underlying conditions, and extensive vascular involvement. Recovery patterns varied, with higher rates of deficits in children younger than one year. The study concluded that moderate-to-severe neurological impairments remain prevalent and that the period between 28 days and one year represents a particularly vulnerable phase (9).

In another study, Yong Kyun Kim et al. compared dysphagia in patients with infratentorial and supratentorial stroke. The study included 64 patients with post-stroke dysphagia (PSD) from 2014 to 2017. The Video Fluoroscopic Swallowing Study (VFSS) was used to assess the severity of dysphagia. The following parameters were measured: Pharyngeal transit time (PTT), post-swallow pharyngeal residue, penetration-aspiration scale (PAS), and functional dysphagia scale (FDS).

All VFSS images were recorded at 30 frames per second, and AutoCAD-based two-dimensional measurements were used to assess post-swallow pharyngeal residue. While PTT and FDS scores did not significantly differ between infratentorial and supratentorial strokes ($P > 0.05$), post-swallow pharyngeal residue and PAS scores were significantly different between the two groups ($P < 0.01$ and $P < 0.05$, respectively) (8).

Sohei Yoshimura et al. investigated the optimal National Institutes of Health Stroke Scale (NIHSS) cut-off values for predicting 90-day clinical outcomes in patients with acute ischemic stroke (AIS) in supratentorial and infratentorial locations. Data were derived from the ENCHANTED trial, an international, multicentre, randomized, quasi-factorial study. Among 2902 patients, those with infratentorial AIS ($n = 289$) had lower baseline NIHSS scores than those with supratentorial AIS ($n = 2613$). The NIHSS cut-off values for predicting poor outcomes were 10 for supratentorial AIS and 6 for infratentorial AIS. No significant differences were observed in functional outcomes or symptomatic intracranial hemorrhage between stroke subtypes (10).

Gordon et al. conducted a prospective longitudinal single-centre study on children diagnosed with first-ever AIS from birth to 18 years. Brain imaging was used to classify lesion characteristics, and children were grouped by age at diagnosis (neonates vs. children older than 30 days).

Among 50 children (mean age 47 months), sensory-motor deficits were more pronounced in older children. At two and six months, motor function was significantly impaired in older children, but no significant cognitive or language impairments were detected. Lesion characteristics alone did not predict adaptive behavioural outcomes at six months (11).

Ryu et al. retrospectively reviewed medical records and neuroimaging of 152 children (1-18 years) diagnosed with stroke between 2000 and 2004. Functional outcomes were assessed using parent-

reported questionnaires, and findings were compared with a previous 2001 study at the same institution. Seventy-eight cases (51.3%) were hemorrhagic strokes, while 74 cases (48.7%) were ischemic strokes. Compared to the earlier study, the incidence of hemorrhagic stroke decreased in children older than ten years, whereas ischemic stroke increased in those younger than ten years. Stroke aetiologies included arteriovenous malformations (42.8%), Moya Moya disease (37.5%), vasculitis (5.3%), cardiac disease (3.9%), hematologic disorders (2.0%), and unknown causes (8.5%).

Common symptoms included headache (53.8%), vomiting (43.6%), and loss of consciousness (28.2%) in hemorrhagic strokes, and hemiparesis (94.6%), headache (35.1%), and speech impairment (31.1%) in ischemic strokes. Acceptable outcomes were observed in 86.0% of hemorrhagic stroke patients and 64.8% of ischemic stroke patients (12).

A 2024 retrospective cross-sectional study evaluated functional outcomes in children and adolescents following stroke. The study included 100 patients (ages 0-21 years) admitted for inpatient stroke rehabilitation. The primary outcome measure was the WeeFIM (Functional Independence Measure for Children) score at admission and discharge. Secondary outcomes included WeeFIM score changes and Inpatient Rehabilitation Facility (IRF) efficiency scores.

Among participants, 56 were male, 43 were female, and one was transgender (mean age 10.4 ± 6.1 years). Stroke subtypes included ischemic (n = 53), hemorrhagic (n = 41), and hemorrhagic transformation of ischemic stroke (n = 6). At admission, moderate-to-severe functional impairments were present (WeeFIM total score: 26.3 ± 47.9). The mean length of rehabilitation stay was 28.6 ± 34.1 days, and the WeeFIM total score improved to 31.5 ± 73.2 at discharge (13).

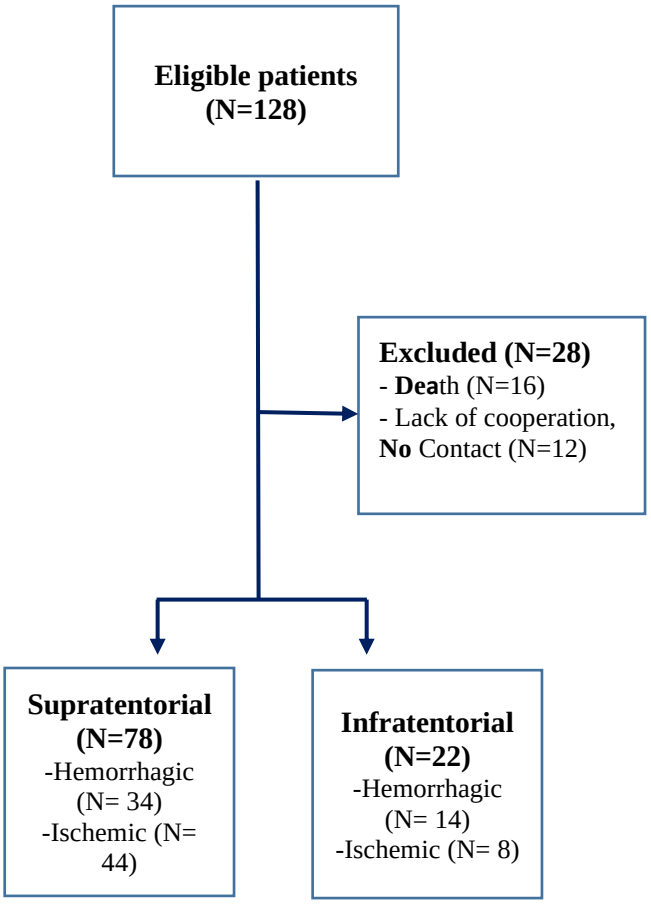
Anna N. et al. conducted a prospective longitudinal study to examine the relationship between neurological impairment and 12-month functional outcomes. The study included children hospitalized with AIS at the Royal Melbourne Hospital between 2007 and 2013. Neurological impairments were assessed at four-time points (acute, 1, 6, and 12 months) using PSOM or AIS recovery questionnaires.

Children were grouped by age at diagnosis (neonates, preschool-age, school-age) for analysis. Sixty-four children (27 neonates, 19 preschool-age, 18 school-age) were included. Median PSOM scores were highest in the acute phase for preschool-and school-age children, followed by a decreasing trend over time, with the lowest scores at 12 months.

Neonates had a median PSOM score of 0 across all time points, indicating minimal detectable deficits. PSOM impairments at one month were associated with lower fine motor z-scores, gross motor impairments, and adaptive behaviour deficits at 12 months (14).

Results

Out of 128 patients hospitalized for stroke at two centers (Rasul-e-Akram and Ali Asghar hospitals), 100 met the inclusion criteria for the study. Sixteen patients had passed away (10 boys and 6 girls), and 12 patients were excluded due to non-cooperation, lack of access, or failure to return for follow-up.



The average age of the patients was 70.47 months, with a standard deviation of 63.89 months. 57% of the patients were over two years old, and 67% were male. 78% of the participants had supratentorial strokes. The age group classification: 44 (56.4%) patients with Supratentorial stroke aged more than two years, and 27 patients (34.6%) were female, 34%. 51 (65.4%) of patients in this group were male. Thirteen (59.1%) patients with Infratentorial stroke were aged more than two years, and nine (40.9%) with less than two years (P-value: 0.83). Female patients with infratentorial

stroke included six (27.3%) patients, and male patients 16 (72.7%) (P-value: 0.128).

The comparison shows no significant difference between the genders in the two groups, although the proportion of males was slightly lower in the supratentorial group compared to the infratentorial group (P=0.128).

Hemorrhagic strokes were more common in the infratentorial region (63.6%) compared to the supratentorial region (43.6%) (P-value: 0.096).

Ischemic strokes were more frequent in the supratentorial region (56.4%) than in the infratentorial region (36.4%).

Table 1: Comparison of Bayley Scores (7-Category Scale) Between Supratentorial and Infratentorial Groups

	Extremely	Borderline	Low	Average	High	Superior	Very	Total	P-value
Supratentorial	5 (14.7)	3 (8.8)	7 (20.6)	14 (41.2)	3 (8.8)	1 (2.9)	1 (2.9)	34 (100)	
Infratentorial	1 (11.1)	0	1 (11.1)	1 (11.1)	1 (11.1)	4 (44.4)	1(11.1)	9 (100)	0.023
Total	6(14.0)	3 (7.0)	8 (18.6)	15 (34.9)	4 (9.3)	5 (11.6)	2 (4.7)	43 (100)	

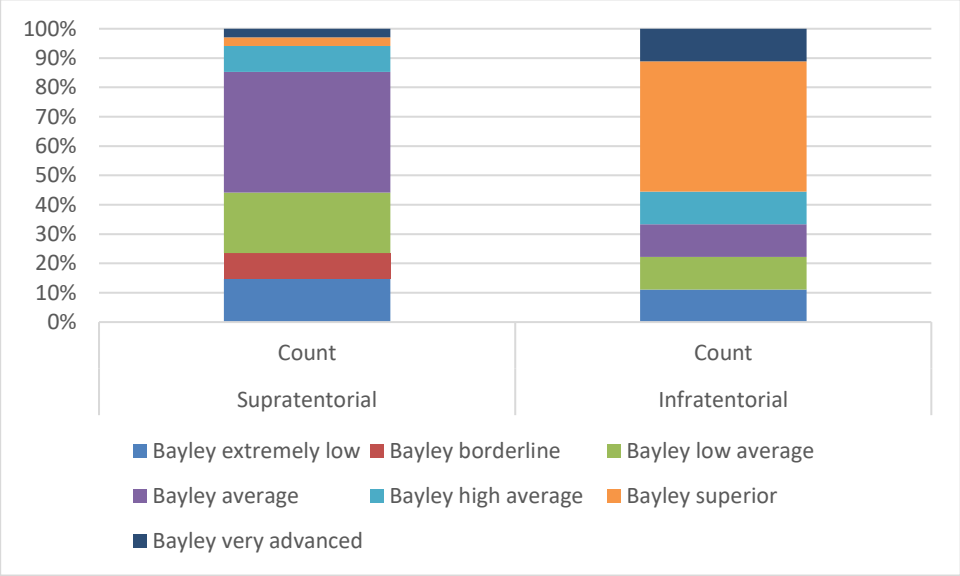


Figure 1: Comparison of Bayley Scores (7-Category Scale) Between Supratentorial and Infratentorial Groups

Table 2: Comparison of Bayley Scores (3-Category Scale) between Supratentorial and Infratentorial Groups

	Low/Extremely low	Average	High/Extremely High	Total	P-value
Supratentorial	8 (23.5)	24 (70.6)	2 (5.9)	34 (100)	0.002
Infratentorial	1 (11.1)	3 (33.3)	5 (55.6)	9 (100)	
Total	9 (20.9)	27 (62.8)	7 (16.3)	43 (100)	

A statistically significant difference was found in Bayley scores between the two groups when assessed using the 7-category scale (P = 0.023). The supratentorial group showed moderate scores, whereas the infratentorial group scored higher in some categories.

In the 3-category scale evaluation, a significant reduction in Bayley scores was observed in the supratentorial group (P=0.002).

No statistically significant differences were observed between the two groups, whether in the 8-category or 3-category scales of the Binet Score.

Table 3 shows the comparison of MRS scores between the Supratentorial and Infratentorial groups. The P-value indicates that the Supratentorial group had significantly higher MRS scores than the Infratentorial group, with a P-value of 0.001, which is statistically significant. The actual data would need to be inserted for precise interpretation.

The results of this study indicated no significant difference in the underlying diseases between the two groups of patients with supratentorial and infratentorial lesions. The prevalence of various diseases in both groups is presented, and the P-value for all cases is reported as non-significant, suggesting that the observed differences may be due to chance rather than a statistically valid correlation.

Additionally, underlying diseases are categorized into broader groups such as coagulopathies, hematologic malignancies, infectious diseases, and trauma. Again, no significant differences were observed between the two groups.

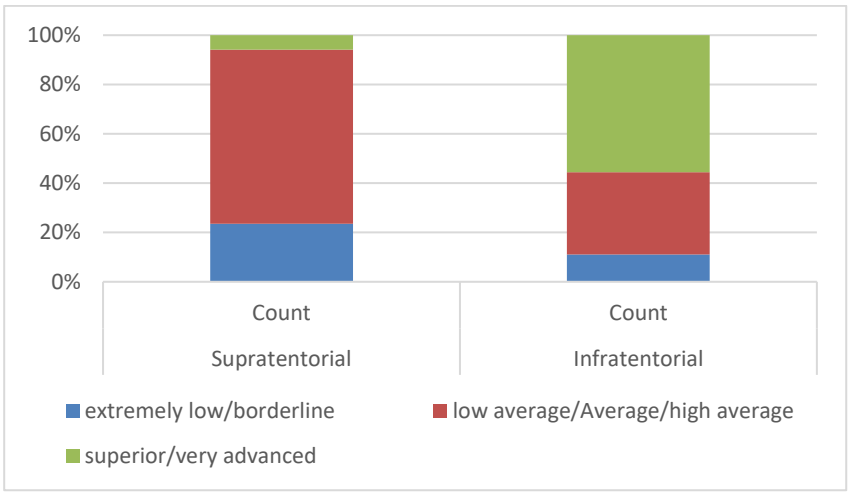


Figure 2: Comparison of Bayley Scores (3-Category Scale) Between Supratentorial and Infratentorial Groups

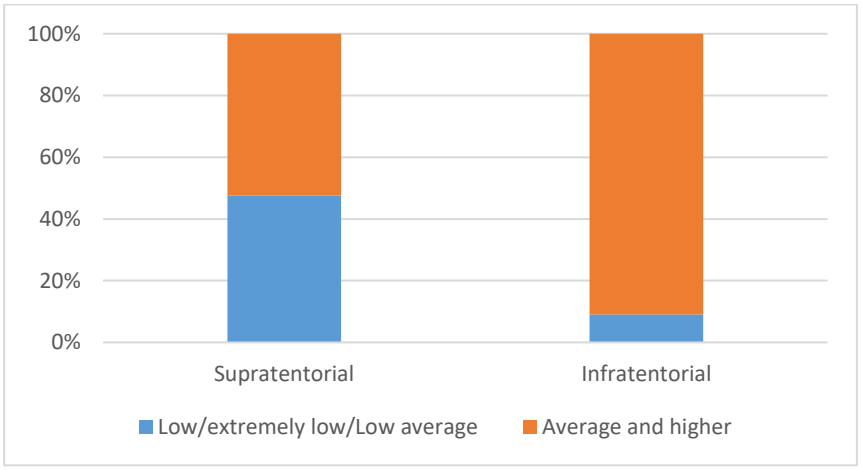


Figure 3: Comparison of Bayley Scores (2-Category Scale) between Supratentorial and Infratentorial Groups

Table 3: Comparison of Benet Scale Scores (8-Category Scale) Between Supratentorial Groups

	Moderately impaired or delayed	**Mildly impaired or delayed**	**Borderline impaired or delayed**	**Low average**	**Average**	**High average**	**Superior**	**Very advanced**	**Total**	**P-value**
Supratentorial	2 (4.5)	1(2.3)	1 (2.3)	4 (9.1)	17(38.6)	14(36.8)	3(6.8)	2(4.5)	44(100	
Infratentorial	0	0	1(7.7)	0	3(23.1)	7(7.7)	1(7.7)	1(7.7)	13	0.64
Total	2(3.5)	1(1.8)	2(3.5)	4(7.0)	20(35.1)	21(36.8)	4(7.0)	3(5.3)	57(100	

Therefore, the type of underlying disease does not seem to substantially impact the distribution of supratentorial and infratentorial lesions.

This study aimed to compare the outcomes of children under 18 years with stroke in supratentorial and infratentorial regions, focusing on motor and cognitive impairments 24 months after the stroke. It

reviewed the electronic hospital records of stroke patients from Ali Asghar and Rasul-e-Akram hospitals between 2011 and 2023, and finally, 100 eligible patients with an average age of 5.87years participated in this study.

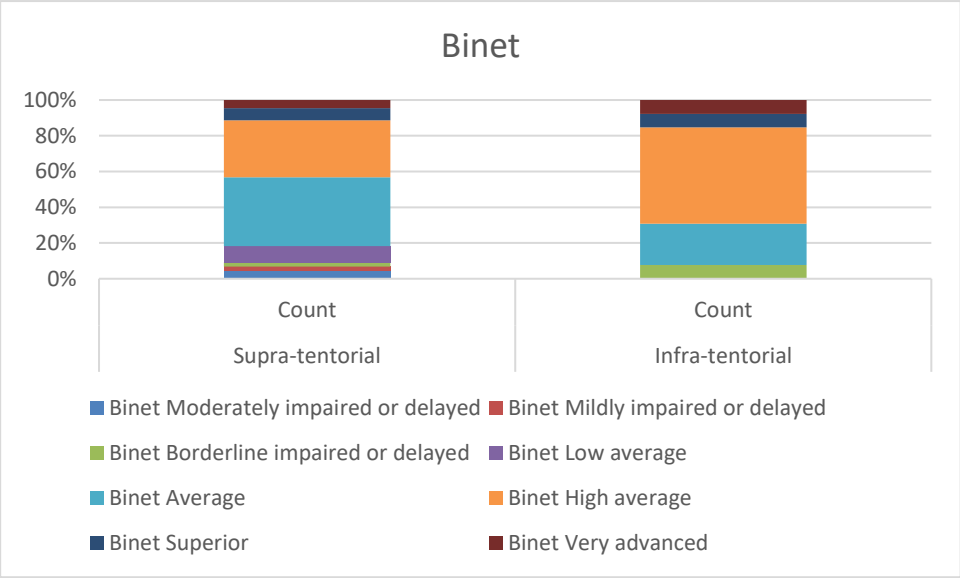


Figure 4: Comparison of Binet Scores (8-Category Scale) between Supratentorial and Infratentorial Groups

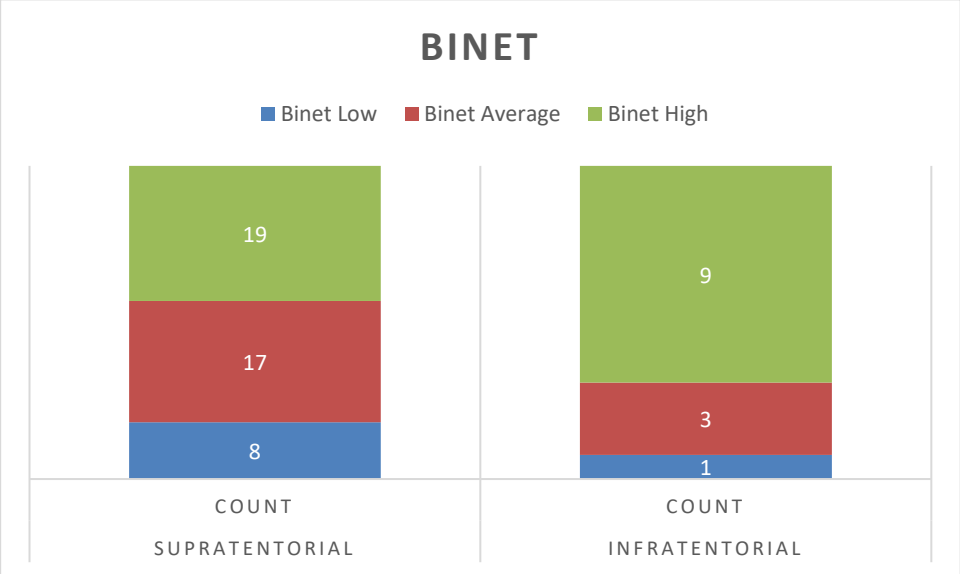


Figure 5: Comparison of Binet Scale (3-Category) Between Supratentorial and Infratentorial Groups

Table 3: Comparison of MRS Scores between Supratentorial and Infratentorial Groups

	0	**1**	**2**	**3**	**4**	**5**	**Total**	P-value
Supratentorial	5 (6.4)	9 (11.5)	20 (25.6)	27 (34.6)	10 (12.8)	7 (9)	78 (100)	0. 24
Infratentorial	5 (22.7)	5 (22.7)	9 (40.9)	1 (4.5)	2 (9.1)	0	22	
Total	10	14	29	28	12	7	100	

Most studied patients had strokes in the supratentorial region, consistent with existing evidence. The prevalence of stroke in children significantly varies based on location in the brain, specifically between the supratentorial and infratentorial regions. Studies show that nearly 80% of strokes in children occur in the supratentorial region, while about 20% of strokes occur in the infratentorial region (23-25).

Infratentorial strokes typically affect the brainstem and cerebellum, and due to their vital role in autonomic functions and motor control, they result in more severe neurological deficits such as dysphagia and coordination problems. In contrast, supratentorial strokes, more common in older children, lead to varied outcomes depending on the specific brain areas involved, such as the frontal or parietal lobes. The increased vascular supply and collateral circulation in the supratentorial region may provide protective advantages against ischemic damage compared to the infratentorial region, which has less collateral flow and is more prone to ischemic events (8, 26, 27).

The assessment of motor and cognitive impairments in the study participants revealed that the supratentorial group had significantly lower Billy scale scores and higher MRS scores. This indicates that motor and cognitive impairments were more severe in the supratentorial group compared to the infratentorial group.

In a similar study, Boulouis et al. conducted a comprehensive analysis of non-traumatic ICH in children, including various causes and developmental-neurological outcomes. This study included a group of children with supratentorial ICH, examining the occurrence of motor impairments such as cerebral palsy and cognitive deficits following the hemorrhage. The key findings showed that children with supratentorial strokes had a higher prevalence of motor impairments, including hemiparesis and spasticity, as well as cognitive deficits measured by standardized neuropsychological assessments. Specifically, the study reported that about 45% of pediatric patients with supratentorial ICH had motor impairments, while 38% experienced significant cognitive challenges. The study by Rees and colleagues found that children who had perinatal strokes showed a 61% incidence of hemiplegia and a significant reduction in IQ. These children also demonstrated poorer academic performance and lower language scores, highlighting the multifaceted impact of stroke on cognitive and motor development (28).

Overall, the results of studies clearly indicate that stroke in children is a major determinant of motor and cognitive impairments, with significant consequences for neurological development and quality of life. The enduring nature of these cognitive impairments requires comprehensive, long-term neuropsychological support and interventions tailored to the specific needs of affected children (29, 30).

In Conclusion

In general, although published evidence confirms the link between pediatric strokes and subsequent motor and cognitive impairments, few studies have examined these impairments based on the stroke location. A notable gap in research exists, particularly regarding how different stroke regions correlate with distinct patterns of motor and cognitive dysfunction in pediatric populations, highlighting the need for further investigations in this area.

The limitations of the present study primarily stem from challenges related to parental cooperation and incomplete patient records. Additionally, incomplete patient records posed another limitation: Missing data on important variables such as precise medical history, stroke characteristics, and follow-up outcomes affected our analysis and conclusions. Furthermore, the relatively short follow-up period may not capture the full spectrum of recovery or long-term outcomes associated with pediatric strokes, as cognitive and motor impairments may emerge over time. Future research should focus on larger sample sizes, longer follow-up, and examining stroke outcomes based on the timing of the stroke.

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Authors' contributions

VM and AT designed the study. MK analyzed and interpreted the patient’s data. LT and RA were major contributors in writing the manuscript. All of authors read and approved the final manuscript

Conflict of Interests

The authors declare no conflict of interest in preparing this study.

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