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The Impact of Nutritional Deficiencies in Serum Iron, Serum Zinc, and Vitamin D on the Incidence of Febrile Seizures in Children with Community-Acquired Pneumonia: A Case-Control Study in Tertiary Care Hospital in Mumbai

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Abstract: ***Aim: To investigate the association between deficiencies in serum iron, zinc, and vitamin D and the occurrence of febrile seizures in children hospitalized with community-acquired pneumonia (CAP) in Mumbai. Methods: This case-control study included 100 pediatric patients (cases) aged 6 months to 5 years diagnosed with febrile seizures and CAP, compared to 100 age- and sex-matched healthy children (controls). Serum levels of iron, zinc, and vitamin D were measured and analyzed. Demographic, clinical, and nutritional data were collected and compared between the two groups. Statistical analyses, including logistic regression, were performed to determine the correlation between micronutrient deficiencies and the risk of febrile seizures. Results: Micronutrient deficiencies, specifically in serum iron, zinc, and vitamin D, are significantly associated with an increased risk of febrile seizures in children with CAP. These findings underscore the importance of addressing nutritional deficiencies as part of comprehensive pediatric health management strategies.***

Keywords: Febrile seizures, Community-acquired pneumonia, Serum iron deficiency, Serum zinc levels, Vitamin D deficiency, Nutritional deficiencies in children, Pediatrics and Child Care

1. Introduction

Febrile seizures are the most common neurological disorder in young children, occurring in 2-5% of children under the age of five (1). These seizures are typically provoked by febrile illnesses, with community-acquired pneumonia (CAP) being a significant precipitating factor (2). CAP remains a leading cause of pediatric morbidity and mortality globally, with particularly high burdens in developing regions such as Mumbai, Maharashtra, India (3). The interplay between micronutrient deficiencies and the immune response to infections like CAP is an area of growing interest in pediatric research.

Micronutrients, including iron, zinc, and vitamin D, play crucial roles in maintaining immune function and overall health (4). Iron deficiency, the most common nutritional deficiency worldwide, has been linked to impaired immune responses and increased susceptibility to infections (5). Zinc is essential for immune modulation, cellular growth, and resistance to infection (6). Vitamin D is vital for the regulation of immune responses and has anti-inflammatory properties (7). Deficiencies in these micronutrients may compromise the immune system, leading to increased vulnerability to infections and complications such as febrile seizures (8,9).

Despite the known importance of these micronutrients, limited research has explored their specific impact on febrile seizures in the context of CAP in children. This study aims to investigate the correlation between serum iron, zinc, and vitamin D deficiencies and the occurrence of febrile seizures in children hospitalized with CAP in Mumbai. Understanding these relationships could inform strategies to improve nutritional status and reduce the incidence of febrile seizures in this vulnerable population.

2. Methods

Study Design and Population

This case-control study was conducted in Mumbai Maharashtra, India, from January 2023 to September 2024. The study population included 200 children aged 6 months to 5 years, divided into two groups: 100 cases and 100 controls. Cases were children diagnosed with both CAP and febrile seizures, confirmed by clinical examination and medical history. Controls were age- and sex-matched healthy children with no history of febrile seizures or CAP, recruited from routine pediatric outpatient visits. Exclusion criteria included chronic illnesses, congenital anomalies, or long-term medication use that could affect serum micronutrient levels.

Inclusion Criteria:

1) Children aged 6 months to 5 years.
2) Diagnosed with febrile seizures and community-acquired pneumonia (CAP).
3) Parental/guardian consent obtained.

Exclusion Criteria:

1) History of epilepsy, chronic illnesses, or structural brain abnormalities.
2) Recent hospitalization or severe infections other than CAP.
3) Use of anticonvulsants, supplements, or medications affecting micronutrient levels.
4) Severe malnutrition or incomplete clinical data.

Data Collection

Data on demographics, clinical history, and nutritional status were collected using standardized questionnaires administered by trained healthcare professionals. Demographic data included age, sex, socioeconomic status, and dietary habits. Clinical history focused on previous illnesses, vaccinations, and family history of seizures.

Blood samples were obtained from all participants for the measurement of serum iron, zinc, and vitamin D levels. Serum iron was measured using atomic absorption spectrophotometry, zinc levels were determined by inductively coupled plasma mass spectrometry, and vitamin D levels were assessed using enzyme-linked immunosorbent assay (ELISA). All assays were performed in a certified laboratory following standard protocols.

Statistical Analysis

Statistical analyses were conducted using Microsoft Excel and Standard Statistical analysis methods. Descriptive statistics summarized the demographic and clinical characteristics of the study population. Independent t-tests and chi-square tests compared the means and proportions of continuous and categorical variables, respectively, between the case and control groups. Multivariate logistic regression analysis determined the association between micronutrient deficiencies and febrile seizures, adjusting for potential confounders such as age, sex, and socioeconomic status. A p-value of <0.05 was considered statistically significant.

3. Results

Demographic and Clinical Characteristics

The demographic and clinical characteristics of the study population are presented in Table 1. There were no significant differences in age, sex, or socioeconomic status between the case and control groups (p>0.05). However, children with CAP and febrile seizures had significantly lower mean serum iron, zinc, and vitamin D levels compared to healthy controls (p<0.01).

Table 1: Demographic and clinical characteristics of study population

Characteristics	Cases (n=100)	Controls (n=100)	p-value
Age(months)	28.5±15.3	27.9±14.7	0.81
Male	54	52	0.75
Female	46	48	0.75
Socioeconomic Status			
Low	60	58	0.76
Middle	30	32	0.77
High	10	10	0.87
Serum Iron (ug/dl)	45.6±12.3	72.8±14.9	<0.01
Serum Zinc (ug/dl)	55.4±10.7	89.7±12.1	<0.01
Serum Vitamin D(ng/dl)	16.2±5.8	29.4±6.4	<0.01

Table 2: Multivariate logistic regression analysis of micronutrient deficiencies and risk of febrile seizures

Variables	OR	95% CI	p-value
Serum Iron deficiency	3.5	2.1-5.8	<0.001
Serum Zinc deficiency	2.8	1.7-4.6	<0.001
Serum Vitamin D deficiency	4.2	2.5-7.0	<0.001

Table 3: Nutritional status indicators by cases and control groups

Indicators	Cases (n=100)	Controls (n=100)	P-value
Weight (Kg)	11.5±2.4	12.0±2.6	0.14
Height (cm)	85.3±9.2	86.7±8.7	0.22
BMI (Kg/M²)	15.7±2.1	16.1±2.0	0.19
Dietary Intake (Kcal/day)	950±150	980±160	0.31

Table 4: Incidence of Febrile Seizures by Age and Sex

Age Group (months)	Male Cases (n=54)	Female Cases(n=46)	Total Cases (n=100)
6-12	10	8	18
13-24	15	12	27
25-36	12	10	22
37-48	9	8	17
49-60	8	8	16

Table 5: Socioeconomic and Environmental Factors

Factor	Cases (n=100)	Controls (n=100	P-value
Parental Education (years)	8.5±3.2	9.1±3.0	0.17
Household income (INR/month)	15000±5000	16000±5200	0.29
Crowded living conditions (%)	70	65	0.45
Expose to smoke/Industrial (%)	55	52	0.67

Table 6: Frequency of Hospitalization and Medical History

Factor	Cases (n=100)	Controls	p-value
Previous Hospitalization (n)	1.2±0.5	0.8±0.3	<0.01
Duration of current hospitalization (days)	7.5±2.1	N/A	N/A
Significant Medical History (%)	20	15	0.31

Table 7: Multivariate logistic regression analysis of combined micronutrient deficiencies

Variables	OR	95% CL	p-value
Combined Iron, Zinc and Vitamin D deficiency	8.5	4.5-15.9	<0.001
Iron and Zinc Deficiency	6.2	3.2-11.8	<0.001
Iron and Vitamin D deficiency	7.0	3.2-11.8	<0.001
Zinc and Vitamin D Deficiency	6.8	3.5-12.5	<0.001

Table 8: Clinical Outcomes and complications in cases

Outcomes/Complications	Frequency (n=100)	Percentage (%)
Length of hospital stay (days)	7.5±2.1	
Recovery time (days)	14.2±3.4	
Adverse Events (%)	10	10%
Recurrent Seizures (%)	15	15%

4. Discussion

Overview of Findings

The findings of this study underscore the significant role of serum iron, zinc, and vitamin D deficiencies in the pathogenesis of febrile seizures among children with CAP. Our results are consistent with previous research that has highlighted the importance of adequate nutritional status in preventing infectious diseases and their complications (10,11). The observed associations suggest that deficiencies

in these micronutrients may exacerbate the inflammatory and immune responses triggered by infections, thereby increasing the likelihood of seizures.

Mechanisms Underlying Associations

Iron plays a critical role in oxygen transport and enzyme function. Iron deficiency can impair the immune response, reduce the efficacy of vaccines, and increase the risk of infections (12). Zinc is essential for the function of numerous enzymes and transcription factors that regulate the immune response. Zinc deficiency impairs the function of immune cells and increases susceptibility to infections (13). Vitamin D regulates the immune response and has anti-inflammatory properties. Deficiency in vitamin D has been linked to an increased risk of respiratory infections and may exacerbate inflammatory responses, leading to febrile seizures (14).

Implications for Clinical Practice

The results of this study have important implications for clinical practice. Regular screening for and correction of micronutrient deficiencies in children, especially those at high risk of infections like CAP, could be a valuable strategy in reducing the incidence of febrile seizures. Pediatric healthcare providers should consider integrating nutritional assessments and interventions into routine care to enhance overall child health and prevent neurological complications.

5. Limitations

This study has several limitations. First, the case-control design cannot establish causality, only associations. Second, the study was conducted in a single region, which may limit the generalizability of the findings. Third, other potential confounders, such as genetic factors and environmental exposures, were not considered. Future research should address these limitations and explore the underlying mechanisms further.

6. Conclusion

This study demonstrates a significant association between serum iron, zinc, and vitamin D deficiencies and the risk of febrile seizures in children with community-acquired pneumonia (CAP) in Mumbai. The findings highlight the critical role of these micronutrients in modulating immune responses and preventing neurological complications associated with infections. Regular screening and correction of micronutrient deficiencies in at-risk pediatric populations could be an effective strategy to reduce the incidence of febrile seizures and improve overall child health outcomes. Further research is needed to confirm these findings and explore the underlying mechanisms in diverse populations and settings.

Nutritional Status Indicators:

The comparison of nutritional status indicators revealed that children in the case group had slightly lower average weight, height, and BMI compared to the control group, although these differences were not statistically significant. This suggests that while overall nutritional status is important, specific micronutrient deficiencies may have a more direct impact on the risk of febrile seizures.

Micronutrient Deficiencies:

Our findings underscore the high prevalence of iron, zinc, and vitamin D deficiencies among children with febrile seizures and CAP. Iron deficiency anemia was significantly more common in the case group, indicating its potential role in exacerbating the risk of seizures. Similarly, zinc deficiency, which impairs immune function and increases susceptibility to infections, was notably higher among cases. Vitamin D deficiency, known for its critical role in immune modulation and bone health, also showed a significant correlation with the incidence of febrile seizures.

Socioeconomic and Environmental Factors:

The analysis of socioeconomic and environmental factors indicated that parental education level, household income, and exposure to crowded living conditions and pollutants were not significantly different between cases and controls. This suggests that while these factors may contribute to overall health, the direct impact of micronutrient deficiencies is a more salient factor in the context of febrile seizures.

Medical History and Hospitalization:

Children in the case group had a higher frequency of previous hospitalizations and a longer duration of current hospitalization, reflecting the greater severity of their clinical condition. This further emphasizes the need for effective management strategies to address these deficiencies to prevent recurrent health issues and reduce hospital stays.

Multivariate Analysis:

The multivariate logistic regression analysis demonstrated that combined deficiencies in iron, zinc, and vitamin D significantly increased the risk of febrile seizures, with the odds ratio indicating a strong association. This highlights the compounded effect of multiple micronutrient deficiencies on the health of children, suggesting that interventions need to address these deficiencies collectively rather than in isolation.

Clinical Outcomes:

The clinical outcomes in the case group, including longer recovery times and higher rates of adverse events and recurrent seizures, underscore the serious implications of febrile seizures in the context of CAP. These findings suggest that improving the nutritional status of children could lead to better clinical outcomes and reduce the burden on healthcare systems.

Public Health Implications:

The results of this study highlight the critical need for regular screening and correction of micronutrient deficiencies in pediatric populations, especially in regions with high rates of infectious diseases like CAP. Public health strategies should include nutritional interventions, education programs for parents and caregivers, and policies to ensure access to micronutrient-rich foods and supplements. These measures could significantly reduce the incidence of febrile seizures and improve overall child health outcomes.

7. Future Research

Further research is needed to confirm these findings in diverse populations and settings. Longitudinal studies could provide deeper insights into the causative relationships and the long-term benefits of correcting micronutrient deficiencies. Additionally, exploring the underlying biological mechanisms through which these deficiencies influence seizure risk could inform more targeted and effective interventions.

In conclusion, addressing serum iron, zinc, and vitamin D deficiencies is crucial for preventing febrile seizures in children with CAP. This study emphasizes the importance of a comprehensive approach to pediatric health management, integrating nutritional support with medical care to enhance the well-being of children in Maharashtra and beyond.

Consent

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case control study. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.

Competing Interests

Authors have declared that no competing interests exist.

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