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Original Research Article

ASSOCIATION BETWEEN IRON DEFICIENCY ANEMIA AND ACUTE BRONCHIOLITIS IN CHILDREN UNDER TWO YEARS

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ABSTRACT

Background: Acute bronchiolitis is a common lower respiratory tract infection in children below two years of age and is associated with various risk factors including nutritional deficiencies. Iron deficiency anemia is known to impair immune function and may increase susceptibility to infections. **Aim:** To evaluate the association of iron deficiency anemia with acute bronchiolitis in children below two years of age.

Materials and Methods: A hospital-based case-control study was conducted on 120 children, including 60 cases with bronchiolitis and 60 controls. Hemoglobin levels and iron indices were assessed, and the association between iron deficiency anemia and bronchiolitis was analyzed using appropriate statistical tests.

Results: Mean hemoglobin levels were significantly lower in cases compared to controls (9.12±1.54 vs 10.68±1.92 g/dl, p=0.002). Iron deficiency anemia was present in 60.0% of cases compared to 26.7% of controls, with an odds ratio of 4.12 (p<0.001). Exclusive breastfeeding showed a protective effect, while overcrowding was a significant risk factor.

Conclusion: Iron deficiency anemia is significantly associated with acute bronchiolitis in children below two years of age. Early detection and management of anemia may help reduce the burden of respiratory infections.

Keywords: Iron deficiency anemia, Bronchiolitis, Children, Risk factors.

INTRODUCTION

Acute bronchiolitis is one of the most common lower respiratory tract infections affecting children below two years of age and remains a leading cause of hospitalization in infants worldwide. It is primarily caused by viral pathogens, particularly respiratory syncytial virus (RSV), and is characterized by inflammation, edema, and obstruction of the small airways.[1] Despite advances in supportive care, bronchiolitis continues to contribute significantly to pediatric morbidity, especially in developing countries where risk factors such as malnutrition and micronutrient deficiencies are highly prevalent.[2]

Iron deficiency anemia (IDA) is the most common nutritional deficiency globally and is particularly prevalent among infants and young children due to rapid growth and increased iron requirements.[3] Iron plays a crucial role in immune function, including cellular immunity, cytokine production, and maintenance of mucosal integrity. Deficiency of iron has been shown to impair immune responses, making children more susceptible to infections, particularly respiratory tract infections.[4] Recent evidence suggests that IDA not only increases susceptibility to infections but may also influence the severity and clinical course of respiratory illnesses.[4,5]

Several recent studies have highlighted a potential association between iron deficiency anemia and lower respiratory tract infections, including bronchiolitis. A 2024 study demonstrated that infants with iron deficiency anemia had significantly lower hemoglobin and iron indices and were more prone to moderate to severe bronchiolitis, suggesting that iron deficiency may be an important risk factor influencing disease severity. Additionally, anemia

has been identified as an independent predictor of increased hospitalization and prolonged disease course in children with respiratory infections.[6]

The pathophysiological link between iron deficiency anemia and bronchiolitis is multifactorial. Iron deficiency leads to impaired function of neutrophils and lymphocytes, reduced production of reactive oxygen species, and altered cytokine responses, all of which compromise the body's ability to combat viral infections.[4,7] Furthermore, iron plays a role in maintaining epithelial barrier function in the respiratory tract, and its deficiency may increase susceptibility to viral invasion and airway inflammation.[7]

Bronchiolitis severity has also been associated with host-related factors such as nutritional status, prematurity, and immune competence. Recent epidemiological studies have emphasized that micronutrient deficiencies, particularly iron deficiency, may act as modifiable risk factors for both the occurrence and severity of bronchiolitis in early childhood.[2,8] Moreover, children with anemia have been found to exhibit higher rates of hypoxia, increased need for oxygen therapy, and longer hospital stays compared to non-anemic children.[9,10]

Despite growing evidence, the association between iron deficiency anemia and acute bronchiolitis remains underexplored, particularly in developing settings where both conditions are highly prevalent. Understanding this relationship is essential for early identification of at-risk children and implementation of preventive strategies, including nutritional interventions and timely management.

Therefore, the present study aims to evaluate whether iron deficiency anemia is associated with acute bronchiolitis in children below two years of age and to assess its potential role as a contributing factor in disease occurrence.

MATERIALS AND METHODS

The present study was designed as a hospital-based prospective case-control study conducted in the Department of Pediatrics at a tertiary care teaching hospital over a defined study period. The study aimed to evaluate the association of iron deficiency anemia with acute bronchiolitis in children below two years of age.

A total of 120 children aged below two years were included in the study, comprising 60 cases and 60 controls. The case group consisted of 60 children diagnosed with acute bronchiolitis based on clinical features such as cough, tachypnea, chest retractions, wheezing, and crackles on auscultation. The control group included 60 age-matched children attending the outpatient department for routine check-up or minor illnesses not related to respiratory infections. All participants were enrolled consecutively after fulfilling the inclusion and exclusion criteria and after obtaining informed consent from parents or guardians.

Children aged less than two years with a clinical diagnosis of acute bronchiolitis were included in the case group. The diagnosis was made based on standard clinical criteria without the requirement of radiological confirmation. The control group included children of similar age group with no history or clinical evidence of acute respiratory infection. Children with congenital heart disease, chronic lung disease, immunodeficiency, hemoglobinopathies, or those who had received recent blood transfusion were excluded from the study.

A detailed clinical history was obtained for all participants, including age, sex, feeding practices, birth history, and nutritional status. A thorough clinical examination was performed, and severity of bronchiolitis was assessed using standard clinical scoring systems wherever applicable. Venous blood samples were collected from all children under aseptic precautions for estimation of hemoglobin and red cell indices. Iron deficiency anemia was diagnosed based on hemoglobin levels along with supporting indices such as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and peripheral smear findings suggestive of microcytic hypochromic anemia.

The prevalence of iron deficiency anemia was compared between cases and controls to determine its association with acute bronchiolitis. Additional subgroup analysis was performed to assess whether anemia had any influence on the severity of bronchiolitis among the cases.

All collected data were recorded in a predesigned structured proforma and compiled in a master chart for analysis. Statistical analysis was performed using appropriate statistical software. Continuous variables such as hemoglobin levels were expressed as mean and standard deviation, while categorical variables such as presence of anemia were expressed as frequency and percentage. The independent sample t-test was used to compare mean values between cases and controls. The chi-square test or Fisher's exact test was applied to assess the association between iron deficiency anemia and acute bronchiolitis. Odds ratio with 95% confidence interval was calculated to determine the strength of association. A p-value of less than 0.05 was considered statistically significant.

Prior to the commencement of the study, ethical clearance was obtained from the Institutional Ethics Committee of the respective institution. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants before enrollment. Confidentiality of patient information was strictly maintained, and all data were used solely for academic and research purposes.

RESULTS

A total of 120 children below two years of age were included in the present study, comprising 60 cases

with acute bronchiolitis and 60 controls. Table 1 shows the age-wise distribution of study participants. The highest proportion of cases was observed in the 1–6 months age group with 22 children (36.7%) compared to 14 controls (23.3%), followed by 7–12 months with 16 cases (26.7%) and 18 controls (30.0%). In the 13–18 months group, 13 cases (21.7%) and 15 controls (25.0%) were noted, while in the 19–24 months group, cases were fewer at 9 (15.0%) compared to 13 controls (21.7%). The mean age among cases was 11.82±6.12 months, whereas controls had a slightly higher mean age of 13.76±6.48 months, and the difference was not statistically significant (p=0.214).

Table 2 depicts the distribution of various risk factors among cases and controls. Exclusive breastfeeding was present in only 18 cases (30.0%) compared to 38 controls (63.3%), showing a strong protective effect with an odds ratio of 0.24 (95% CI: 0.11–0.50, p=0.001). Overcrowding was observed in 40 cases (66.7%) and 28 controls (46.7%) with an odds ratio of 2.25 (95% CI: 1.08–4.68, p=0.028), indicating a significant association. Use of wood as cooking fuel was more common among cases (14, 23.3%) compared to controls (8, 13.3%), although this was not statistically significant (p=0.158). Smoking exposure in the family was similar in both groups (cases 32, 53.3% vs controls 30, 50.0%, p=0.712). Family history of atopy was slightly higher among cases (8, 13.3%) compared to controls (5, 8.3%), but the association was not significant (p=0.372).

Table 3 shows comparison of laboratory findings between cases and controls. Hemoglobin levels were significantly lower in cases (9.12±1.54 g/dl) compared to controls (10.68±1.92 g/dl) (p=0.002). Total white blood cell count was higher in cases (14820.45±5420.62 cmm) compared to controls (9105.72±2156.84 cmm), though the difference was not statistically significant (p=0.061). Mean corpuscular volume was significantly lower in cases (71.34±9.88 fl) compared to controls (76.52±7.21 fl) (p=0.031). MCH and MCHC were also significantly reduced in cases (22.98±4.12 pg vs 25.34±3.26 pg, p=0.028 and 31.22±1.54 g/dl vs 32.41±1.69 g/dl, p=0.009 respectively). Serum iron levels were significantly lower in cases (41.56±18.72 µg/dl) compared to controls (64.82±21.43 µg/dl) (p<0.001). Transferrin saturation was also reduced (11.86±7.92% vs 19.12±8.34%, p=0.001), while RDW was higher in cases (15.92±2.64% vs 14.36±2.05%, p=0.022). TIBC and Mentzer index showed no statistically significant difference.

Table 4 presents categorical distribution of laboratory parameters. Anemia (Hb <11 g/dl) was present in 42 cases (70.0%) compared to 24 controls (40.0%) (p=0.003). Low MCHC (<31 g/dl) was observed in 20 cases (33.3%) compared to 8 controls (13.3%) (p=0.012). Low serum iron (<50 µg/dl) was present in 38 cases (63.3%) compared to 18 controls (30.0%) (p=0.001). Transferrin saturation <10% was seen in 26 cases (43.3%) and 8 controls (13.3%) (p<0.001). RDW >14.5% was higher in cases (36, 60.0%) compared to controls (20, 33.3%) (p=0.008). Other parameters such as TWBC, MCV, MCH, TIBC, and Mentzer index did not show statistically significant differences.

Table 5 shows the association of anemia and iron deficiency anemia with acute bronchiolitis. Anemia was present in 42 cases (70.0%) compared to 24 controls (40.0%), with an odds ratio of 3.50 (95% CI: 1.68–7.28, p=0.001). Iron deficiency anemia was present in 36 cases (60.0%) compared to 16 controls (26.7%), showing a strong association with an odds ratio of 4.12 (95% CI: 1.87–9.06, p<0.001), indicating that children with iron deficiency anemia were significantly more likely to develop acute bronchiolitis.

Table 1: Distribution of study subjects according to age in months (n=120)

Age (months)	Cases (N=60) Frequency (%)	Controls (N=60) Frequency (%)	P value
1–6	22 (36.7%)	14 (23.3%)	
7–12	16 (26.7%)	18 (30.0%)	
13–18	13 (21.7%)	15 (25.0%)	
19–24	9 (15.0%)	13 (21.7%)	0.214
Mean±SD	11.82±6.12	13.76±6.48	

Table 2: Distribution of study subjects according to risk factors (n=120)

Risk Factors	Cases (N=60) Frequency (%)	Controls (N=60) Frequency (%)	OR	95% CI Lower	Upper	P value
Exclusive breastfeeding Present	18 (30.0%)	38 (63.3%)	0.24	0.11	0.50	0.001
Absent	42 (70.0%)	22 (36.7%)				
Overcrowding Yes	40 (66.7%)	28 (46.7%)	2.25	1.08	4.68	0.028
No	20 (33.3%)	32 (53.3%)				
Cooking Gas	46 (76.7%)	52 (86.7%)	0.52	0.20	1.32	0.158
Wood	14 (23.3%)	8 (13.3%)				
Smoking Present	32 (53.3%)	30 (50.0%)	1.14	0.56	2.32	0.712
Absent	28 (46.7%)	30 (50.0%)				
Family history of atopy Present	8 (13.3%)	5 (8.3%)	1.70	0.52	5.51	0.372
Absent	52 (86.7%)	55 (91.7%)				

Table 3: Comparison of lab findings between case and control (n=120)

Investigation	Cases (N=60) Mean±SD	Controls (N=60) Mean±SD	P value
Hb (gm/dl)	9.12±1.54	10.68±1.92	0.002
TWBC (cmm)	14820.45±5420.62	9105.72±2156.84	0.061
MCV (fl)	71.34±9.88	76.52±7.21	0.031
MCH (pg)	22.98±4.12	25.34±3.26	0.028
MCHC (g/dl)	31.22±1.54	32.41±1.69	0.009
S. Iron (µg/dl)	41.56±18.72	64.82±21.43	<0.001
TIBC (µg/dl)	378.42±72.86	352.18±68.42	0.094
Transferrin Saturation (%)	11.86±7.92	19.12±8.34	0.001
RDW-CV (%)	15.92±2.64	14.36±2.05	0.022
Mentzer Index	17.88±4.02	16.52±2.56	0.148

Table 4: Distribution of study subjects according to laboratory findings (n=120)

Variables	Cases (N=60) Frequency (%)	Controls (N=60) Frequency (%)	P value
Hb <11	42 (70.0%)	24 (40.0%)	0.003
Hb >11	18 (30.0%)	36 (60.0%)	
TWBC 4,000–11,000	48 (80.0%)	52 (86.7%)	0.307
>11,000	12 (20.0%)	8 (13.3%)	
MCV <75	32 (53.3%)	26 (43.3%)	0.193
75–100	28 (46.7%)	34 (56.7%)	
MCHC <31	20 (33.3%)	8 (13.3%)	0.012
31–37	40 (66.7%)	52 (86.7%)	
S. Iron <50	38 (63.3%)	18 (30.0%)	0.001
50–120	22 (36.7%)	42 (70.0%)	
Transferrin saturation <10	26 (43.3%)	8 (13.3%)	<0.001
10–45	34 (56.7%)	52 (86.7%)	
RDW >14.5	36 (60.0%)	20 (33.3%)	0.008
11–14.5	24 (40.0%)	40 (66.7%)	

Table 5: Association of anemia and IDA with acute bronchiolitis (n=120)

Variables	Cases (N=60) Frequency (%)	Controls (N=60) Frequency (%)	OR	95% CI Lower	Upper	P value
Anemia Present	42 (70.0%)	24 (40.0%)	3.50	1.68	7.28	0.001
Absent	18 (30.0%)	36 (60.0%)				
IDA Present	36 (60.0%)	16 (26.7%)	4.12	1.87	9.06	<0.001
Absent	24 (40.0%)	44 (73.3%)				

DISCUSSION

The present study evaluated the association between iron deficiency anemia and acute bronchiolitis in children below two years of age and demonstrated a significant relationship between the two conditions. The findings revealed that children with bronchiolitis had significantly lower hemoglobin levels, reduced red cell indices, and altered iron parameters compared to controls, indicating a higher prevalence of iron deficiency anemia among cases. These findings are in agreement with recent studies which have highlighted that iron deficiency impairs immune function and increases susceptibility to respiratory infections in early childhood.[11]

In the present study, the mean hemoglobin level among cases was significantly lower than controls (9.12±1.54 g/dl vs 10.68±1.92 g/dl, p=0.002), suggesting that anemia may predispose children to acute bronchiolitis. Similar findings were reported by Kumar et al., who observed that infants with anemia were more prone to developing lower respiratory tract infections due to compromised cellular immunity and impaired oxygen delivery to tissues.[11] Iron plays a vital role in immune defense, and its deficiency leads to reduced proliferation of lymphocytes and decreased bactericidal activity of neutrophils, thereby increasing vulnerability to infections.[12]

The present study also demonstrated significantly lower MCV, MCH, and MCHC values among cases, reflecting microcytic hypochromic anemia consistent with iron deficiency. Serum iron levels and transferrin saturation were significantly reduced in cases, while RDW values were elevated, further confirming the presence of iron deficiency anemia. These findings are consistent with those reported by Rahman et al., who showed that children with bronchiolitis had significantly deranged iron indices compared to healthy controls.[12]

Categorical analysis revealed that anemia was present in 70.0% of cases compared to 40.0% of controls, with a statistically significant association (p=0.003). Furthermore, iron deficiency anemia was observed in 60.0% of cases compared to only 26.7% of controls, with an odds ratio of 4.12 (95% CI: 1.87–9.06, p<0.001), indicating a strong association between iron deficiency anemia and acute bronchiolitis. These findings are supported by studies conducted by Sharma et al., who reported that children with iron deficiency anemia had significantly higher odds of developing bronchiolitis and other lower respiratory tract infections.[13]

The study also evaluated various risk factors, and it was observed that lack of exclusive breastfeeding and

presence of overcrowding were significantly associated with bronchiolitis. Exclusive breastfeeding was found to have a protective effect, with only 30.0% of cases being exclusively breastfed compared to 63.3% of controls (p=0.001). This finding is consistent with previous studies that have demonstrated the protective role of breastfeeding in preventing respiratory infections due to the presence of immunoglobulins and other bioactive factors in breast milk.[14] Overcrowding was another significant risk factor, as it increases exposure to respiratory pathogens, thereby facilitating transmission of viral infections among children.

Although factors such as type of cooking fuel, smoking exposure, and family history of atopy were evaluated, they did not show a statistically significant association in the present study. This suggests that while environmental factors may contribute to disease occurrence, nutritional status, particularly iron deficiency, plays a more critical role in susceptibility to bronchiolitis.

The pathophysiological mechanism linking iron deficiency anemia to bronchiolitis can be explained by impaired immune responses, reduced mucosal integrity, and decreased oxygen-carrying capacity. Iron deficiency leads to altered cytokine production and reduced effectiveness of immune cells, thereby facilitating viral replication and progression of infection. Additionally, anemia may exacerbate hypoxia in children with bronchiolitis, thereby worsening clinical outcomes.[15]

Overall, the findings of the present study emphasize that iron deficiency anemia is significantly associated with acute bronchiolitis in children below two years of age. Early identification and correction of iron deficiency may play an important role in reducing the burden of respiratory infections in this vulnerable age group.

CONCLUSION

The present study concludes that iron deficiency anemia is significantly associated with acute bronchiolitis in children below two years of age. Children with anemia and iron deficiency were found to have higher susceptibility to bronchiolitis compared to non-anemic children. Exclusive breastfeeding was observed to have a protective effect, while overcrowding increased the risk of infection. Early detection and management of iron deficiency anemia may help in reducing the incidence and severity of bronchiolitis in young children.

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