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Correlation of White Blood Cell Count and Hemoglobin Levels with Disease Severity in Pediatric Otitis Media

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Abstract

Pediatric otitis media is a widespread infectious disease, where systemic inflammatory reactions can affect disease severity, and the evaluation of white blood cell count and hemoglobin levels might be useful markers of inflammatory load and disease progression. This study aimed to assess the relationship between disease severity and white blood cell count and hemoglobin levels in pediatric otitis media, and approve their potential as simple indicators of disease severity. This hospital-based case-control study was conducted from 13 April to 20 November 2025 in the ENT Consultancy Unit of Al-Habboubi Teaching Hospital, Iraq. The study included 75 children clinically diagnosed with otitis media and 30 age- and sex-matched healthy controls under 12 years of age. Diagnosis was established by otoscopic examination. Bacterial identification from middle ear samples was performed using standard culture media. Hematological parameters were determined using automated analyzers, and disease severity was classified into mild, moderate, and severe forms. Baseline comparability between patients and controls was adequate, with no significant differences in sociodemographic characteristics. The most common pathogen identified was *Streptococcus pneumoniae*, followed by *Haemophilus influenzae* and *Moraxella catarrhalis*. Patients showed significantly higher white blood cell counts and neutrophil proportions, accompanied by lower hemoglobin and lymphocyte levels, indicating a neutrophil-dominant inflammatory response. White blood cell and neutrophil counts were positively correlated with disease severity, whereas hemoglobin and lymphocyte levels showed negative correlations, suggesting inflammation-related anemia in severe cases. In conclusion, this study showed that pediatric otitis media associated with severity-related systemic inflammation characterized by elevated white blood cell and neutrophil counts and reduced hemoglobin levels. These findings reflect inflammatory anemia mediated by cytokine activity and hepcidin-related iron sequestration.

Keywords: : Pediatric otitis media; White blood cell count; Hemoglobin; Disease severity; Inflammation .

Introduction

Otitis media (OM) is a highly prevalent infectious disease in children across the globe and one of the primary causes of outpatient practice, prescription of antibiotics, and

referrals in children. It is most common in early childhood because of anatomical and immunological causes, such as the immaturity of the Eustachian tube, high rates of exposure to infections of the upper respiratory tract, and immature immune response (1). Regardless of the improvements in vaccination measures and antimicrobial treatment, OM remains a major clinical and population health issue, particularly in the low- and middle-income nations where repeated infections and complications are more prevalent (2). The clinical features of otitis media have a broad range of severity, with one end of the scale consisting of mild and self-limiting inflammation and the other end of the scale constitutes an in-depth disease that is linked with systemic symptoms, recurring episodes, and comorbidities that can impact hearing and language development (3,4). Proper evaluation of severity of the disease is thus crucial in informing clinical decision-making, treatment strategy optimization, and defining children who are more likely to have worse outcomes. Although otoscopic results and clinical manifestation continue to be the foundation of diagnosis, there is a growing focus on determining the simple laboratory tests, which mirror the underlying inflammatory load and can be further correlated with the severity of the disease (5). White blood cell (WBC) is a well-established indicator of systemic inflammation and host immune response to infection. With bacterial infections, especially respiratory tract infections, the increased WBC counts, which are often associated with neutrophilia, are an indication of innate immune system activation and bone marrow production of inflammatory cells (6,7). Bacterial pathogenic factors in pediatric otitis media like *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis* trigger the production of pro-inflammatory cytokines, which result in the release of leukocytes and the intensification of the response to the injury (8). A number of studies have indicated that the increased WBC counts might be linked to some serious or complex types of infection; nevertheless, the information correlating the WBC levels with graded severity of the otitis media in children is scanty and not consistent (9). Hemoglobin concentration, in turn, is conventionally measured within the framework of nutritional status and hematologic conditions yet there is a growing body of evidence that describes its sensitivity to inflammatory mechanisms. Inflammatory acute and chronic processes are capable of decreasing the measure of hemoglobin in the processes collectively known as anemia of inflammation (10). These processes consist of suppression of erythropoiesis by action of cytokines, decreased red blood cell survival, and amplified production of hepcidin, decreasing iron availability via reducing intestinal absorption and retaining iron in macrophages. Repeated infections or sever infections in pediatric populations may worsen this process especially in the conditions where the iron stores are marginal. However, the connection between the clinical severity of otitis media and the level of hemoglobin was not studied in detail (11). The relationship between WBC count, hemoglobin levels, and disease severity in pediatric otitis media could yield useful data on how the condition affects the body-wide system that is thought to be a localized infection. It is possible that by determining relationships between these easily measured hematologic parameters and clinical severity, it would be feasible to use them as supplemental instruments in risk stratification, in disease progression, and possibly in treatment intensity (12). Additionally, these indicators are specifically appealing in the resource-deprived environment, where not only the use of the sophisticated diagnostic tools but also their accessibility can be limited (13). Although this clinical subject is of clinical importance, only a limited number of studies have assessed inflammatory responses by leukocytes and changes in hemoglobin as it relates to the severity of the disease in children with otitis media simultaneously (14). The existing literature tends to pay attention to the microbiological patterns, risk factors, or treatment outcomes being

less concerned with the area of integrated hematological profiling. There is also a difference in study design, population, and definition of severity which has led to inconsistent findings in reports (15). Consequently, this study intended to evaluate the white Blood Cell Count and Hemoglobin Levels and their correlation with Otitis Media Severity in children.

Methodology

This study approved by the Human ethics committee of Al-Habboubi Teaching Hospital. All participants signed written informed consent before its enrolment. The research ensured the privacy of the information of subjects.This research paper was formulated as a case-control study in a hospital setting between 13 April 2025 to 20 November 2025 in the Otolaryngology (ENT) Consultancy Unit of Al-Habboubi Teaching Hospital, Nasiriyah, Iraq. The sample of the given study included 75 children with the diagnosis of otitis media and 30 seemingly healthy children who acted as controls. Children of less than 12 years were included. Patients were recruited sequentially according to a known clinical diagnosis of otitis media identified by specialist otolaryngologists using a detailed medical history, physical examination, and otoscopic appearance of inflammation of the tympanic membrane, effusion, bulging, or purulent discharge with or without systemic manifestations. Children whose systemic illnesses were chronic or had other ear deformities, a blood transfusion in the past two weeks, or had been under antibiotic treatment in the past two weeks were also disqualified. Control subjects consisted of age- and sex-matched children visiting the hospital to have regular checkups and did not have a history or clinical manifestation of ear infection or general inflammatory diseases. In the case of microbiological analysis, the middle ear specimens were aseptically collected using sterile swabs either on ear discharge or middle ear effusion where available, and directly transported to the microbiology laboratory and inoculated on blood agar, chocolate agar, and MacConkey agar plates. Plates were incubated at 37 ^{O}C for 24-48 hours. The morphology of the colonies, Gram stain and basic biochemical tests were identified for bacterial isolates. The hematological studies were conducted on venous blood samples that had been taken under aseptic conditions. Complete blood count parameters, such as total white blood cell count and percentage of different leukocytes, were performed by an automated hematology analyzer. While, hemoglobin concentration was determined by the use of standard calibrated methods. The clinical classification of the severity of the disease was carried out into mild, moderate, and severe manifestations depending on the severity of symptoms, otoscopic changes, and systemic manifestations. All the laboratory works were conducted on the basis of standardized procedures to make it accurate and reproducible.

Statistical analysis

Spreadsheets were used to analyze quantitative data that were displayed as SPSS version 26. The expressions of results were in terms of frequencies and percentages. Two-tailed independent and paired t-tests were used to analyze parametric data whereas the Mann–Whitney U test, Wilcoxon test and Chi-square test were used to analyze non-parametric data as deemed necessary. A p-value less than 0.05 was taken as significant.

Results

The Baseline comparison between study groups was the age, sex, residence, prior otitis media history, and passive smoking exposure. The sociodemographic analysis in table 1, showed that the age (4.7 ± 1.8 vs. 5.0 ± 1.9 years; p = 0.458), gender distribution (p = 0.952), and place of residence (p = 0.941) were not statistically significant when comparing children with otitis media and healthy controls. The recurrent nature of the disease was observable in a large percentage of patients with a history of the previous incidences of otitis media reported in 38.7 percent of the affected children. Passive smoking exposure was found more in patients with otitis media than in controls (34.7% vs. 23.3%), which was also not statistically significant (p = 0.261). These results indicate that the effects of demographic and environmental variables were not likely to confound any clinical and hematological difference between study groups.

Table 1: Sociodemographic and Clinical Characteristics of Children with Otitis Media and Healthy Controls

Variable	Otitis Media Patients (n = 75)	Healthy Controls (n = 30)	p-value
Age (years), Mean ± SD	4.7 ± 1.8	5.0 ± 1.9	0.458
Gender (Male/Female), n (%)	43 (57.3%) / 32 (42.7%)	17 (56.7%) / 13 (43.3%)	0.952
Residence (Urban/Rural), n (%)	47 (62.7%) / 28 (37.3%)	19 (63.3%) / 11 (36.7%)	0.941
Previous OM episodes, n (%)	29 (38.7%)	—	—
Passive smoking exposure, n (%)	26 (34.7%)	7 (23.3%)	0.261

Frequency and percentage of bacterial species identified among otitis media patients (n = 75)

Microbiological analysis in table 2, showed that the most commonly isolated pathogen was the *Streptococcus pneumoniae* (33.3%) and then *Haemophilus influenzae* (22.7%) and *Moraxella catarrhalis* (18.7%). *Staphylococcus aureus* was found in 13.3% of isolates and *Pseudomonas aeruginosa* was found in 8.0% of isolates. The smaller percentage of patients also experienced mixed bacterial infections (4.0%). On balance, the obtained results showed that the prevalence of classical otopathogenic bacteria was observed in the context of pediatric cases of otitis media, which contributes to the importance of common respiratory pathogens in disease pathogenesis.

Table 2: Distribution of Bacterial Pathogens Isolated from Children with Otitis Media

Bacterial Species	Frequency (n)	Percentage (%)
Streptococcus pneumoniae	25	33.3
Haemophilus influenzae	17	22.7
Moraxella catarrhalis	14	18.7
Staphylococcus aureus	10	13.3
Pseudomonas aeruginosa	6	8.0
Mixed bacterial infection	3	4.0
Total	**75**	**100**

Differences in white blood cell count, hemoglobin levels, and leukocyte differentials between study groups

The hematological results in table.3, showed significant discrepancies between children with otitis media and normal children. The white blood cell count in patients was much higher than in controls (13.4 ± 3.2 vs. 7.3 ± 1.5 $\times 10^3$ /mL; $p < 0.001$), through which the systemic inflammatory response increased. The level of hemoglobin was greatly lower in the group of the patient (10.8 ± 1.1 g/dL) compared to controls (12.7 ± 1.0 g/dL; $p < 0.001$), which served to indicate the presence of inflammation-related anemia. Also, neutrophil percentages were also found to be significantly higher in patients (68.5 ± 9.4) than controls (52.2 ± 7.6; $p < 0.001$), whereas lymphocyte percentages were significantly lower (24.1 ± 6.8) in patients than in controls (38.6 ± 8.1). All of these data show a neutrophil-dominating inflammatory pattern in otitis media in children.

Table 3: Comparison of Hematological Parameters Between Otitis Media Patients and Healthy Controls

Parameter	**Patients (n = 75) Mean ± SD**	**Controls (n = 30) Mean ± SD**	**p-value**
WBC ($\times 10^3/\mu L$)	13.4 ± 3.2	7.3 ± 1.5	<0.001
Hemoglobin (g/dL)	10.8 ± 1.1	12.7 ± 1.0	<0.001
Neutrophils (%)	68.5 ± 9.4	52.2 ± 7.6	<0.001
Lymphocytes (%)	24.1 ± 6.8	38.6 ± 8.1	<0.001

Distribution of white blood cell count and hemoglobin levels across disease severity categories

Hematological parameters in table 4, were analyzed based on the severity of the disease and a clear and statistically significant pattern was identified. The levels of white blood cells were rising in mild to severe otitis media (10.9 ± 2.1, 13.6 ± 2.4, and 16.1 ± 3.0 x10 3 /uvL, respectively; $p = 0.001$), and this was a progressive inflammatory reaction with higher severity of the disease. Comparatively, hemoglobin levels showed a strong inverse, with values of 11.6 ± 0.9 g/dL, 10.8 ± 1.0 g/dL and 10.1 ± 1.1 g/dL in mild, moderate, and severe cases respectively ($p < 0.001$). The results support the hypothesis, showing that an increase in the severity of disease in pediatric otitis media is correlated with the increase in systemic inflammation and the coinciding drop in the level of hemoglobin.

Table 4: Association Between Disease Severity and Hematological Parameters in Pediatric Otitis Media

Disease Severity	**n (%)**	**WBC ($\times 10^3/\mu L$) Mean ± SD**	**Hemoglobin (g/dL) Mean ± SD**
Mild (n = 22)	29.3%	10.9 ± 2.1	11.6 ± 0.9
Moderate (n = 31)	41.3%	13.6 ± 2.4	10.8 ± 1.0
Severe (n = 22)	29.3%	16.1 ± 3.0	10.1 ± 1.1
p-value	—	<0.001	<0.001

Pearson correlation analysis of inflammatory and hematological markers in relation to disease severity score

The correlation analysis in table 5, revealed that there are significant relationships between hematological parameters and the severity of the disease in children with otitis media. Severity score was positively correlated with white blood cell count ($r = +0.64$, $p < 0.001$), and the more the disease was severe the more the systemic inflammation. Likewise, percentage of neutrophil was associated with severity positively ($r = +0.58$, $p < 0.001$). Conversely, hemoglobin levels showed a moderate negative association with disease severity ($r = -0.51$, $p < 0.001$), which indicated that the hemoglobin level was depleting with an increase in the severity of the disease. The percentage of lymphocytes also had a negative correlation with severity score ($r = −0.46$, $p < 0.001$). These results indicated an inflammatory response and inflammatory-related anemia in more severe manifestations of pediatric otitis media, which was neutrophil-dominated.

Table 5: Correlation Between Hematological Parameters and Disease Severity in Pediatric Otitis Media

Parameter	r-value	p-value
WBC count vs severity score	+0.64	<0.001
Hemoglobin vs severity score	−0.51	<0.001
Neutrophil percentage vs severity	+0.58	<0.001
Lymphocyte percentage vs severity	−0.46	<0.001

Discussion

The current results showed a consistent clinical-microbiological-hematological image of pediatric otitis media (OM), where baseline comparability increased the internal validity of biomarker-severity relationships. The results showed no considerable differences between patients and controls in terms of age, sex, and residence. These groups observations and hematological differences are worked well in the future and are not likely to be influenced by demographic imbalance. A relative abundance of children with a history of previous episodes of OM (38.7% is also in line with the established susceptibility of OM to recur in early childhood because of poor functioning of the Eustachian tube, the common occurrence of upper respiratory infections by viruses and ongoing colonization of the nasopharynx. Even though exposure to passive smoking was more prevalent in cases of OM compared to controls, they were statistically non-significant. This potentially directional, yet insignificant, trend can be credibly attributed to lack of statistical power in small effect sizes, possible under-reporting of household smoke exposure, and heterogeneity of exposure intensity/duration. Notably, much of the epidemiologic evidence on secondhand smoke being a causative factor in middle ear disease and recurring ear infections has been supported using extensive epidemiologic data most notably when maternal smoking is taken into account [16], and more recent burden analyses have indicated significant OM as a result of exposure to secondhand smoke around the world (17). Thus, non-significant p-value may not mean that there is no effect, but it may be due to potential exposure misclassification and sample-size limitations compared to a true underlying relationship.

Bacterial profile showed dominance of classical otopathogens, which were included *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*. These are consistent with culture-based and clinical series revealing that these bacteria are significant contributors to the pathogenesis of OM in children (18). However, in modern literature, a shift in some locations to much higher amounts of *H. influenzae* and much less *S. pneumoniae* in the OM isolates has been reported following the introduction of a post-pneumococcal conjugate vaccine (PCV). This movement is also noticed within the confines of relatively smaller areas of the population (19). However, a general finding in highly vaccinated populations is the dominance of *H. influenzae* in complicated/recurrent disease necessitating surgical intervention (20). The prevalence of *S. pneumoniae* as the most common isolate can perhaps represent local immunization rates, the serotypic dynamics of the serotype, and pre-sampling trends of antibiotic exposure, as well as the laboratory methodology (e.g. culture sensitivity; prior antibiotic use decreases recovery of more fastidious organisms). Case mix variation is also important: studies with enriched severe, persistent or surgically treated OM usually have different distributions than the acute presentations in an outpatient setting (21). This occurrence of *S. aureus* and *Pseudomonas aeruginosa* in few cases could be an indication of recurrent disease, otorrhea, a history of exposure to antimicrobials, or contamination of the external canal; however, it could also represent local epidemiology in which the organisms are more commonly recovered in complicated OM or in chronic suppurative disease (22).

Hematological analyses (Table 3) indicated a strong inflammatory profile in OM patients having increased WBC counts accompanied by neutrophilia and relative lymphopenia supporting an acute inflammatory response to bacteria. The pattern is biologically in line with granulopoiesis and neutrophil demargination mediated by cytokines during bacterial infection and with redistribution of lymphocytes during stress and inflammation. This interpretation is reinforced by the severity-stratified analysis ,which shows graded increase of WBC with mild to severe disease. These results indicated the increasing of the systemic inflammatory activation with clinical severity. Associations of comparable severity have been noted in the case of neutrophil/lymphocyte-related measures of leukocyte-derived indices in the case of otitis media phenotypes, which underlies the idea that peripheral inflammatory markers may indicate disease burden (23,24). Moreover, further evidences supported by the correlation results and increasing in severity, which were observed as the proportion of WBC and neutrophils and a decrease in lymphocytes percentage. These results are consistent with previously reported study approved the neutrophil dominant inflammatory environment (25).

The negative correlation between hemoglobin and OM severity was also observed in this study. Although OM is traditionally viewed as a local infection, systemic inflammation has the potential to cause anemia of inflammation by upregulating hepcidin via IL-6 to restrict iron supply by inhibiting intestinal absorption and retaining iron within macrophages, therefore inhibiting erythropoiesis (26). Hematology reviews focus on hepcidin ferroportin axis maladjustment as a fundamental process which connects infection/inflammation to reduced hemoglobin and functional iron limitation (27). This effect can be enhanced by repeated infections and inflammation in children, particularly in children with a marginal state of baseline nutritional iron status. Reductions in hemoglobin are less frequently observed in those studies that do not monitor hemoglobin, and those studies that do monitor hemoglobin involve milder outpatient cases, different age distributions or improved nutritional/iron status; more successful results are obtained with cohorts with recurrent or severe infections (28). Therefore, the variation among reports can be attributed to variations in disease phenotype (acute vs recurrent/chronic),

the time of sampling of blood in relation to the onset of the illness, the prevalence of iron-deficiency backgrounds, and confusing variables that are not directly quantifiable (e.g. dietary consumption or parasitism) (29).

The results of the current study, supported a model according to which pediatric OM, was mainly caused by classical respiratory otopathogens, induces systemic neutrophil-predominant inflammation. It was developed in proportion to clinical severity and also accompanied by a decrease in hemoglobin. These findings indicated that available hematological markers including WBC differentials counts and hemoglobin could be considered to support the clinical, whereas microbiologic investigations remain very important in the setting of vaccination and antimicrobial pressure (30).

Conclusion

The results of the current study approved the relationship between pediatric otitis media and the severity-dependent systemic inflammatory reaction accompanied with raising in white blood cell and neutrophil counts and a decrease in the amount of hemoglobin levels. The study approved the possibility of using these routine hematological parameters as indicators for the severity of otitis media in children.

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Competing interest's statement
The authors declare that they have no competing interests

Ethics statement
The Human ethics committee of Al-Habboubi Teaching Hospital approved the study. All participants or/and their legal guardians were informed of the study objectives and procedures and written informed consent was obtained before its enrolment. The research ensured the privacy of the information of subjects.

Author contributions
Author contribution should be mentioned for each author such as :
ASN. & SQM, design of the work; acquisition, analysis, and interpretation of data;
M.N.A &R.F.M, drafting the work and revising it critically for important intellectual content. All the researchers revised the entire manuscript and approved its publication.

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