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Original Research Article

Assessment of Packed Cell Volume, Total and Differential White Blood Cell Counts in Patients Diagnosed with Alzheimer's Disease in Owerri, Nigeria

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Abstract

Background: *Alzheimer's disease (AD) is a progressive neurodegenerative condition increasingly recognized in sub-Saharan Africa. Hematological changes may reflect systemic inflammation and immune alterations associated with the disease.* ***Objective:*** *To assess packed cell volume (PCV), total and differential white blood cell (WBC) counts in patients with Alzheimer's disease in Owerri, Nigeria.* ***Methods:*** *A cross-sectional case-control study was conducted among 30 AD patients and 30 age- and sex-matched healthy controls. Informed consent was obtained from the participants and samples were collected aseptically and analyzed using standard operating procedures. Hematological parameters including PCV, total WBC, neutrophils, lymphocytes, monocytes, eosinophils, and basophils were analyzed. Statistical significance was set at $p < 0.05$.* ***Results:*** *The mean values of PCV (27.40±4.97) %, lymphocytes (26.40±9.03) % and monocytes (1.97±2.32) % were significantly lower in Alzheimer's disease patients when compared to the controls (34.53±3.33) % (48.60±7.09) % and (6.23±3.78) ($p = 0.000$). That of TWBC (13.69±4.50) $x10^9$/L and neutrophils (70.77±9.96) % were significantly raised in Alzheimer's disease patients when compared to the controls (7.45±2.29) $x10^9$/L and (43.70±7.40) % ($p = 0.000$). There was no significant difference in the mean values of eosinophils (0.83±0.79)% and basophils (0.67±1.83)% in Alzheimer's disease patients when compared to the controls (1.20±0.96)% and (0.10±0.40)% ($p= 0.112$ and $p = 0.102$), and no significant difference in the mean values of PCV (28.36 ± 5.66)%, TWBC (14.93 ± 4.64) x 10^9/L, neutrophils (70.81 ± 11.28)%, Lymphocytes (26.27 ± 10.01)%, monocytes (2.00 ± 1.48)%, eosinophils (0.73 ± 0.79)% and basophils (0.27 ± 0.65)% in males with Alzheimer's disease when compared to females (26.84 ± 4.59)%, (0.89 ± 0.81)% and (0.89 ± 2.23)% respectively ($p = 0.429$, $p = 0.258$, $p = 0.983$, $p= 0.954$, $p = 0.946$, $p = 0.586$, and $p = 0.378$). There was no significant difference in the mean values of PCV (27.30 ± 2.87)%, TWBC (12.94 ± 4.41) $x10^9$/L, neutrophils (73.00 ± 9.45)%, lymphocytes (22.70 ± 7.41)% monocytes (3.00 ± 2.87)% and eosinophils (1.00 ± 0.82)% and basophils (0.20 ± 0.63)% of ages (40 - 60) years when compared to ages (>60) years (27.53 ± 5.89)%, (14.17 ± 4.62) x 10^9/L,(69.59 ± 10.30)%, (28.37 ± 9.55)% and (1.42 ± 1.54)% respectively ($p = 0.910$, $p = 0.496$; $p = 0.390$, $p = 0.114$, $p = 0.062$, $p = 0.413$ and $p = 0.311$), and a non-significant positive correlation of PCV with TWBC($r = 0.34$, $p = 0.066$), neutrophils ($r = 0.25$, $p = 1.87$), lymphocytes ($r = 0.21$, $p = 0.257$), monocytes ($r = 0.16$, $p = 0.410$), eosinophils ($r = 0.07$, $p = 0.713$) and basophils ($r = 0.09$, $p = 0.604$) respectively.* ***Conclusion:*** *Altered hematologic profiles, particularly anemia and elevated neutrophil counts, may characterize systemic involvement in AD. These parameters could serve as potential adjunctive indicators in the management of Alzheimer's disease in sub-Saharan populations.*

Keywords: *Packed Cell Volume, Total White Blood Cell, Differential White Blood Cells, Alzheimer's Disease.*

1. INTRODUCTION

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by cognitive decline, memory impairment, and functional disability, predominantly affecting the elderly population. Globally, AD is one of the leading causes of dementia, accounting for 60-80% of all cases, with an estimated 55 million people living with dementia worldwide as of 2020, and this number is expected to rise with increasing life expectancy, particularly in low- and middle-income countries (1). Nigeria, like many sub-Saharan African countries, is experiencing a demographic shift with a growing elderly population, raising the burden of age-related disorders such as AD (2).

The pahophysiology of Alzheimer's disease involves complex mechanisms including amyloid-β plaque deposition, neurofibrillary tangles, oxidative stress, and chronic inflammation (3). Increasing evidence suggests that systemic immune responses and hematological changes may play a role in the disease's progression and severity. Changes in hematological parameters such as packed cell volume (PCV), white blood cell (WBC) counts, and differentials have been explored in neurodegenerative diseases to understand the systemic impact of central nervous system pathology (4,5).

Previous studies have reported alterations in hematological profiles among AD patients, with some noting increased inflammatory markers and leukocytosis, suggesting systemic inflammation (6). Other studies have observed decreased PCV and altered lymphocyte counts, which may reflect immune dysregulation and potential comorbidities such as anemia of chronic disease or nutritional deficiencies (7). However, data from sub-Saharan Africa, including Nigeria, remain scarce. This study aims to assess the PCV, total and differential WBC counts in patients with Alzheimer's disease in Owerri, Nigeria, and compare findings with age - and sex - matched healthy controls, contributing to the limited regional data and potentially aiding clinical evaluation strategies.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at Federal Teaching Hospital, Owerri, Imo State, Nigeria.

2.2 Study Design

This was a cross-sectional, case-control study carried out from the month of January to March, 2024 at Federal Teaching Hospital, Owerri, Imo State, Nigeria. A total of 60 participants were enrolled, comprising 30 clinically diagnosed Alzheimer's disease patients (based on DSM-5 criteria and neurologist confirmation) and 30 age- and sex-matched apparently healthy controls. Participants were recruited from neurology clinics. The results of the tests were analyzed using SPSS version 25.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria for the AD group included confirmed diagnosis of Alzheimer's disease, age 40 years and above, and consent to participate. Controls were cognitively intact individuals with no known history of neurodegenerative, hematological, or systemic inflammatory disorders. Exclusion criteria included active infections, autoimmune diseases, cancer, hematologic disorders, or recent blood transfusion.

2.4 Sample Collection

Venous blood samples (5 mL) were collected aseptically from each participant into EDTA-containing tubes. Samples were analyzed within 2 hours using an automated hematology analyzer (e.g., Mindray BC-5150) to determine the packed cell volume (PCV), total white blood cell (WBC) count, and differential WBC counts (neutrophils, lymphocytes, monocytes, eosinophils, and basophils). Quality control protocols were followed strictly throughout the analyses.

2.5 Ethical Consideration

Ethical approval for this study was obtained from the Ethics Review Committee of Federal Teaching Hospital, Owerri, Nigeria. All participants provided written informed consent before inclusion in the study.

2.6 Laboratory Analysis

The determination of haematological parameters was done using haematology autoanalyzer.

2.7 Statistical Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD). The Shapiro-Wilk test was used to assess normality. Differences between Alzheimer's patients and controls were evaluated using the independent samples t-test for normally distributed variables, and the Mann–Whitney U test for non-normally distributed data.

3. RESULTS

Table 1: Mean Values of PCV, TWBC, Neutrophils, Lymphocytes, Monocytes, Eosinophils and Basophils in Alzheimer's Disease Patients and the Controls.

Parameter	Test	Control	t-value	p-value
PCV (%)	27.40±4.97	34.53±3.33	6.53	0.000*
TWBC ($x10^9$/L)	13.69±4.50	7.45±2.29	6.76	0.000*
Neutrophils (%)	70.77±9.96	43.70±7.40	11.94	0.000*
Lymphocytes (%)	26.40±9.03	48.60±7.09	10.59	0.000*
Monocyte (%)	1.97±2.32	6.23±3.78	5.27	0.000*
Eosinophils (%)	0.83±0,79	1.20±0.96	1.61	0.112
Basophils (%)	0.67±1.83	0.10±0.40	1.66	0.102

Key:

PCV: Packed Cell Volume

TWBC: Total White Blood Cell

*: Significant p-value

The mean values of PCV (27.40±4.97) %, lymphocytes (26.40±9.03) % and monocytes (1.97±2.32) % were significantly lower in Alzheimer's disease patients when compared to the controls (34.53±3.33) % (48.60±7.09) % and (6.23±3.78) (t = 6.53, p = 0.00, t = 10.59, p = 0.00 and t = 5.27, p = 0.000). That of TWBC (13.69±4.50) $x10^9$/L and neutrophils (70.77±9.96) % were significantly raised in Alzheimer disease patients when compared to the controls (7.45±2.29) $x10^9$/L and (43.70±7.40) % (t = 6.76, p = 0.000, and t = 11.94, p = 0.000).

There was no significant difference in the mean values of eosinophils (0.83±0.79) % and basophils (0.67±1.83) % in Alzheimer's disease patients when compared to controls (1.20±0.96) % and (0.10±0.40) % (t = 1.61, p= 0.112 and t = 1.66, p = 0.102).

Table 2: Mean Values of PCV, TWBC, Neutrophils, Lymphocytes, Monocytes, Eosinophils and Basophils in Male and Female Alzheimer's Disease Patients.

Parameter	Male	Female	t-value	p-value
PCV (%)	28.36±5.66	26.84±4.59	0.80	0.429
TWBC ($x10^9$/L)	14.93±4.64	12.97±4.38	1.15	0.258
Neutrophil s(%)	70.81±11.28	70.74±9.45	0.021	0.983
Lymphocytes (%)	26.27±10.01	26.47±8.70	0.06	0.954
Monocytes (%)	2.00±1.48	1.95±3.74	0.06	0.946
Eosonophils (%)	0.73±0.79	0.89±0.81	0.55	0.586
Basophils (%)	0.27±0.65	0.89±2.23	0.89	0.378

Key:

PCV: Packed Cell Volume

TWBC: Total White Blood Cell

There was no significant difference in the mean values of PCV (28.36 ± 5.66)%, TWBC (14.93 ± 4.64) x 10^9/L, neutrophils (70.81 ± 11.28)%, Lymphocytes (26.27 ± 10.01)%, monocytes (2.00 ± 1.48)%, eosinophils (0.73 ± 0.79)% and basophils (0.27 ± 0.65)% in males with Alzheimer's disease when compared to females (26.84 ± 4.59)%, (0.89 ± 0.81)% and (0.89 ± 2.23)% respectively (t = 0.80, p = 0.429. t = 1.15, p = 0.258, t = 0.021, p = 0.983 and t = 0.06, p= 0.954, t = 0.06, p = 0.946, t = 0.55, p = 0.586, t = 0.89, p = 0.378).

Table 3: Mean Values of PCV, TWBC, Neutrophils, Lymphocytes, Eosinophils and Basophils in Alzheimer's Disease Patients based on Age.

Parameter	(40-60)years	(>60)years	t-value	p-value
PCV (%)	27.30±2.87	27.53±5.89	0.14	0.910
TWBC (x10^9/L)	12.94±4.41	14.17±4.62	0.69	0.496
Neutrophils (%)	73.00±9.45	69.58±10.30	0.87	0.390
Lymphocytes (%)	22.70±7.41	28.37±9.55	1.63	0.114
Monocytes (%)	3.00±2.87	1.42±1.54	1.95	0.062
Eosinophils (%)	1.00±0.82	0.74±0.81	0.83	0.413
Basophils (%)	0.20±0.63	0.95±2.22	1.03	0.311

Key:

PCV: Packed Cell Volume

TWBC: Total White Blood Cell

There was no significant difference in the mean values of PCV (27.30 ± 2.87)%, TWBC (12.94 ± 4.41) X $10^{9/L}$, neutrophils (73.00 ± 9.45)%, lymphocytes (22.70 ± 7.41)% monocytes (3.00 ± 2.87)% and eosinophils (1.00 ± 0.82)% and basophils (0.20 ± 0.63)% of ages (40 - 60) years when compared to ages (>60) years (27.53 ± 5.89)%, (14.17 ± 4.62) x 10^9/L,(69.59 ± 10.30)%, (28.37 ± 9.55)% and (1.42 ± 1.54)% respectively (t = 0.14, p = 0.910; t = 0.69, p = 0.496; t = 0.87, p = 0.390, t = 1.63, p = 0.114, t = 1.95, p – 0.062, t = 0.83, 0.413 and t = 1.03, p = 0.311).

Table 4: Correlation of PCV with TWBC, Neutrophils, Lymphocytes, Monocytes, Eosinophils and Basophils in Alzheimer's Disease Patients

Dependent variable	n	r	p-value
TWBC (x10^9/L)	30	0.34	0.066
Neutrophils (%)	30	0.25	0.187
Lymphocytes (%)	30	0.21	0.257
Monocytes (%)	30	0.16	0.410
Eosonophils (%)	30	0.07	0.713
Basophils (%)	30	0.09	0.604

There was a non-significant positive correlation of PCV with TWBC(r = 0.34, p = 0.066), neutrophils (r = 0.25, p = 1.87), lymphocytes (r = 0.21, p = 0.257), monocytes (r = 0.16, p = 0.410), eosinophils (r = 0.07, p = 0.713) and basophils (r = 0.09, p = 0.604) respectively.

4. DISCUSSION

The results of this study demonstrated significantly lower levels of PCV, lymphocytes, and monocytes in Alzheimer's disease patients compared to controls, while total WBC counts and neutrophils were significantly elevated. These findings suggest a pattern of systemic inflammation and possible immune dysregulation in AD patients, consistent with the neuroinflammatory hypothesis of Alzheimer's disease.The elevated total WBC count and neutrophilia observed in this study align with previous findings that suggest chronic inflammation plays a central role in the pathogenesis of Alzheimer's disease. For example, Qin et al. (8) reported increased peripheral neutrophil counts in AD patients, correlating with disease progression and suggesting that innate immune activation might contribute to neurodegeneration. Similarly, Leung et al. (9) highlighted that higher neutrophil-to-lymphocyte ratios (NLR) are indicative of systemic inflammation in AD and are associated with cognitive decline.

Conversely, the observed lymphopenia and monocytopenia in our study are also supported by prior research. In a study by Rentzos et al. (10), lower lymphocyte counts were reported in AD patients, which the authors attributed to chronic immune exhaustion or redistribution of lymphocytes to the central nervous system. Monocytes, which serve as precursors to microglia, are also found in reduced peripheral levels in some neurodegenerative conditions, potentially due to increased trafficking to the brain where they participate in inflammatory responses (11).

The significantly reduced PCV among Alzheimer's patients suggests the presence of anemia, which has been previously associated with cognitive decline and dementia. Shah et al. (12) found a strong association between low hematocrit levels and cognitive impairment in elderly individuals, positing that reduced oxygen-carrying capacity of blood may exacerbate neurodegeneration. However, whether anemia is a contributing factor or a consequence of AD remains unclear.

No significant differences were observed in hematological parameters when stratified by sex or age groups (40 – 69 years vs. ⩾60 years), indicating that the alterations in blood profiles are likely related to disease pathology rather than demographic variables. This observation is consistent with findings from Fabbri et al. (13), who found minimal impact of age or sex on WBC profiles in AD patients after adjusting for comorbidities.

Furthermore, the lack of significant correlation between PCV and other hematological parameters suggests that anemia in AD may be multifactorial and not directly linked with leukocyte dynamics. This aligns with the findings of Atti et al. (14), who found that anemia in AD patients could be due to nutritional deficits, chronic inflammation, or underlying renal or bone marrow dysfunction, rather than alterations in immune cell counts alone.

While eosinophils and basophils were insignificantly reduced in this study, their roles in Alzheimer's disease remain poorly understood, with limited literature addressing their contribution to neurodegeneration. Some studies have suggested that these granulocytes might play minor roles in chronic inflammation, but further research is needed to clarify their relevance (15).

Therefore, the hematological profile of Alzheimer's disease patients in Owerri, Nigeria, indicates a pro-inflammatory state characterized by elevated neutrophils and total WBCs, and suppressed lymphocytes and monocytes, with accompanying anemia. These findings support the systemic involvement in AD and underscore the need for comprehensive hematologic assessments in managing patients with Alzheimer's disease.

5. CONCLUSION

Altered hematologic profiles, particularly anemia and elevated neutrophil counts, may characterize systemic involvement in AD. These parameters could serve as potential adjunctive indicators in the management of Alzheimer's disease in sub-Saharan populations. Routine evaluation of hematologic profiles in AD patients may provide useful insights into disease progression, systemic involvement, and potential therapeutic targets. Further longitudinal studies and mechanistic investigations are warranted to elucidate the causal relationships between these hematologic changes and neurodegeneration in Alzheimer's disease.

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