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Research Article

Immuno-Hematological Profiles of Ethiopian Cutaneous Leishmaniasis Patients before and During Treatment with Sodium Stibogluconate

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Abstract

Background: Leishmania parasite is known to secrete surface proteins that help evade the host's immune response. After anti-leishmaniasis therapy, the disease can persist, particularly under immunosuppression, leading to a high risk of relapse. Neutrophils are the first responders followed by macrophages and dendritic cells, but sand fly saliva inhibits their effectiveness. In Ethiopia, Sodium Stibo Gluconate (SSG) is commonly used to treat Cutaneous Leishmaniasis (CL). But, much is not known about patients' immuno-hematological profiles before the initiation of treatment and during treatment. We hypothesized that treatment would enhance the immuno-hematological profile of Ethiopian CL patients.

Materials and Method: A longitudinal study was conducted from September 2022 to August 2024 at Adiss Alem Primary Hospital in Bahir Dar city, northwest Ethiopia. A total of 96 CL patients participated in the study. Blood samples (5 ml) were drawn and analyzed within one hour using an automated hematology machine CC20 Plus. One-way ANOVA was employed for comparing mean values with confidence level of 95%. Variables were declared statistically significant if their p-values are less than 0.05.

Result: Three forms of CL where observed with a median age of 25 years. Treatment of CL patients with SSG led to a significant decline in cellular mean absolute number, comparing of the time period before treatment initiation with that of on treatment at 28 days. The fall in count of WBC, was seen from 6.63 to 5.2×10^6; Lymphocyte, from 2.38 to 1.54×10^3; and Granulocyte, from 4 to 3×10^3 respectively. All these reduction over time down the treatment period was statistically significant ($p<0.05$).

Conclusion: Patients with CL often endure lesions for extended periods before receiving treatment at health facility. Following treatment with SSG, there is a notable decrease in most immuno-hematological cell profiles. Interestingly, platelet counts increased over time, indicating a positive response to the treatment.

Recommendation: To ensure homeostasis and competent immune function in CL patients on SSG treatment, supplementary medications should be included to prevent immune suppression. Exploring alternative treatments for CL management is crucial.

Keywords: Cellular profile • Cutaneous leishmaniasis • Ethiopia • Sodium stibogluconate • Treatment

Background

Leishmaniasis is a disease form and caused by the Leishmania parasite, affects millions globally, it appeared in various clinical forms from mild skin lesions to serious tissue damage Promastigotes of Leishmania, injected by a sand fly, differentiate to non-motile amastigotes, in the host, that can replicate within the vacuoles Persistent Vegetative State' (PVs). Sandfly can inject 10 to 100,000 parasites to the host. Cutaneous Leishmaniasis (CL) causes skin ulcers and the healing time influenced by species, health, and nutrition status. The host–parasite interactions can lead to a series of events, culminating in the different forms of clinical manifestations [1-4].

Leishmania secretes surface proteins, forming a glycocalyx that modulates host cell signaling and enhances protection. It can persist lifelong; immunosuppressed individuals are at risk for reactivation. Certain macrophage, dendritic cells, and fibroblast subpopulations act as safe niches for parasite survival.

The control of Leishmania infection is dependent on cellular immune mechanisms. Neutrophils are first responders to infections, but sand fly saliva hinders macrophage anti-leishmanial activity and promotes neutrophil apoptosis, that result inhibition of macrophages, aiding parasite survival while attracting dendritic cells for a potential Th1 response. In the other hand, human leishmaniasis, NK cells quickly accumulate at the infection site, producing IFN-γ to enhance macrophage microbicidal activity.

Regarding T-lymphocytes, CD4 T cells are essential for controlling parasite growth in leishmaniasis, while CD8 T-cells display both protective and pathological functions. Protective acquired immunity against Leishmania relies on CD4+ and CD8+ T-cells producing Th1 cytokines like IFN-γ and IL-12. This triggers anti-leishmanial responses, inducing iNOS and oxidative bursts, thereby reducing parasitaemia. In contrast, Th2 cytokines (IL-4, IL-

13) and IL-10 can result in disease progression and non-curing outcomes. The treatment regimen of CL in Ethiopia, according to the diagnosis and treatment guideline, there are 3 treatment options: To withhold treatment, use topical or local treatment, and treatment with systemic drugs [5].

This study aimed to investigate the immuno-hematological profile of CL patients before and during treatment with intramuscular sodium Stibo Gluconate (IM SSG). We hypothesized that treatment would enhance the immuno-hematological profile and increase the absolute cell counts over the course of therapy in Ethiopian CL patients.

Materials and Method

Study area and setting: This hospital-based study was conducted at Adiss Alem Primary Hospital in Bahir Dar city, northwest Ethiopia. The hospital serves patients coming from a catchment area of nearly 300,000 people. It has provided treatment for both cutaneous and visceral Leishmaniasis since its establishment.

Source population: All patients who visited the hospital in the study period were the source population.

Study population: Patients of cutaneous leishmaniasis who were attending CL treatment in the study period.

Study participants: CL patients who were confirmed with microscopic investigation and having the amastigote stage of the parasite and consented to participate in the study and who full filled the inclusion criteria.

Inclusion and exclusion criteria: Patients with visible skin lesions as confirmed by laboratory for cutaneous leishmaniasis or clinical evaluations across all ages were included, while those with HIV, hepatitis, or TB were excluded.

Study design and period: The study deploys a longitudinal cohort study that covers CL patients who came to the hospital between September 2022 to August /2024.

Sample size determination: Single population proportion formula were used to determine the sample size estimation, it was conducted based on the cure rate at T2 (end of 30 day), aiming for a precision of 10%. Utilizing a 95% confidence level and a conservative assumption of a 50% cure rate, the calculated sample size was 96 patients [6].

P=50% (0.5), prevalence of CL patients who was expected to get improved

d=10%, level of precision, and at 95% CI- a 5% level of significant-

$$\frac{n = z^2\alpha / 2 \times P \times q}{d^2}$$

In this formula, q implies, =1-p. The estimate finally computed as

$(1.96)^2 \times (0.5) \times (0.5)/(0.1)^2=96$

Dependent and independent variables: The dependent variables were the immuno-hematological parameters (cell count) and the independent variables are age, sex, CL type, duration of illness, treatment option.

Diagnosis and treatment of Leishmaniasis cases: Patients diagnosis was done by a microscopic identification of a leishmania amastigote from the skin scraping smear and the parasite load was graded as per the guideline [7,8]. Parasite grading: Parasite grade (PG) 6+ = >100 parasites per field, 5+ = 10–100 parasites per field, 4+ = 1–10 parasites per field, 3+ =1–10 parasites per 10 field, 2+=1–10 parasites per100 field, 1+ =1–10 parasites per 1000 field, negative =0 parasite per 1000 field.

In this study the CL patients were treated with SSG Intramuscular (20 mg/kg/day) for 28 days and Paromomycin was used to treat for those sever and repeat patients with SSG.

Data collection, analysis and quality assurance: Epidemiological data on age, sex, occupation, and disease onset were collected through questionnaires. Clinical classification, laboratory grading, and cell counts were assessed by senior dermatology staff and laboratory personnel. Blood samples were taken in EDTA vacuum tubes and analyzed within an hour using the Micro-CC20 Plus blood counter, following a quality assurance protocol. Patients receiving SSG treatment were admitted for monitoring during daily rounds and provided balanced meals. Data were entered into Excel and analyzed with SPSS (2023) using one-way ANOVA and post hoc tests, skewed distributions addressed via Ln-logarithm transformation. The median and Interquartile Range (IQR) were used to illustrate population distribution.

Ethical issues: This study ethically cleared and approved by Amhara Public Health Institute (NoH/R/T/T/D/07/83) support letter APHI 03/1691. All data obtained from study were made anonymous.

Operational definitions

Improvement of hematological profile (Treatment response): Leishmaniasis treatment improvement expected within two weeks of starting anti-leishmaniasis medicines, with complete recovery might take four to six weeks. Based on this assumption, we assessed at two critical points after therapy initiation. T0 is the initial evaluation, involving a Complete Blood Cell Count (CBC) upon diagnosis of CL. T1 is the second CBC test performed 14 days to 15 days after starting SSG, enabling early assessment of treatment response. T2 is the final CBC conducted 29 days to 30 days post-SSG initiation, coinciding with treatment completion. This structured approach is effective in monitoring the patient's recovery during the treatment period and profiling the immune-hematological profile parameters of CL patients following the treatment at different time points.

Result

The burden of CL: The disease primarily affected younger individuals, with a median age of 25 years (IQR=25.7) and a median disease onset at 8 months (IQR=7). Half of the patients had been ill for eight months, opting to stay home. The study focused on different forms of Cutaneous Leishmaniasis (CL), with most diagnosed with Mucocutaneous Leishmaniasis (MCL). Notably, 65.6% of patients preferred traditional treatments over modern options (Table 1).

A 10-year-old child with a nose lesion experienced anxiety during traditional medicine treatment. Plant juice accidentally dripped on his face, causing irritation. Within days, a significant scar formed, restricting facial movement and causing ongoing discomfort. This has affected the child's daily life and overall well-being, highlighting the impact of the incident on his emotional and physical health (Figure 1).

Figure 1. Cutaneous leishmaniasis lesions and traditional practice: 1(a) Localized Cutaneous Leishmaniasis. 2(b) Mucocutaneous leishmaniasis. 3(c) Cutaneous Leishmaniasis patients who used traditional medicine. 4(d) Defused Cutaneous Leishmaniasis patients.

Table 1. Demographic and clinical variables.

Variable		Frequency	%
Sex	F	35	36.5
	M	61	63.5
	Total	96	-
CL type	LCL	32	33.3
	MCL	60	62.6
	DCL	4	4.1
	Total	96	-
Laboratory grading	1+	16	39
	2+	6	14.6
	3+	6	14.6
	4+	5	12.2
	5+	6	14.6
	6+	2	5
	Total	41	-
	No grading but positive	55	-
Treatment for CL	SSG	91	95
	SSG + Paromomycin	5	5
	Total	96	-
Practice of traditional medicinal plants	Yes	63	65.6
	No	33	34.4
	Total	96	-
Residence	Urban	12	12.5
	Rural	84	87.5
	Total	96	-

Absolute numbers of immuno-hematological parameters at different time points

Patients with CL undergoing SSG treatment had regular immune hematological assessments. Over 95% adhered to the treatment. Laboratory results revealed a significant decrease in White Blood Cells (WBC), Red Blood Cells (RBC), and lymphocytes after one month compared to baseline. Conversely, platelet counts increased steadily throughout treatment. This difference in platelet dynamics highlights the complex interactions within the hematological system in response to SSG therapy (Table 2).

Table 2. Comparison of median and mean values with different time points.

Variables	Stastical Value	Time Serious, Following Treatment		
		T0:	T1: Median	T2:
WBC ×10³/mm³	Median (IQR)	6.09 (2.82)	5.63 (2.54)	5.3 (1.33)
	Mean (± SD)	6.63 (2.2)	5.7 (1.9)	5.2 (1.4)
	95% CI for mean	6.13-7.13	5.17-6.28	4.69-5.77
Lymphocytes ×10³/mm³	Median (IQR)	2.31 (0.98)	1.6 (0.74)	1.51 (0.73)
	Mean (± SD)	2.38 (0.88)	1.92 (1.94)	1.54 (0.6)
	95% CI for mean	2.16-2.61	1.27-2.56	1.26-1.81
Granulocytes ×10³/mm³	Median (IQR)	3.83 (3.75)	3.97 (2.54)	2.81 (1.42)
	Mean (± SD)	4.02 (2)	3.66 (1.7)	3.09 (1.1)
	95% CI for mean	3.39-4.66	2.93-4.39	2.47-3.7
Hemoglobin (g/dl)	Median (IQR)	14.2 (2.4)	13.75 (2.45)	13.9 (2.92)
	Mean (± SD)	14.4 (1.6)	13.6 (1.7)	13.5 (1.80
	95% CI for mean	14.04-14.81	13.13-14.18	12.85-14.27
RBC ×10⁶/mm³	Median (IQR)	4.81 (0.74)	4.71 (0.73)	4.63 (0.9)
	Mean (± SD)	4.84 (0.62)	4.66 (0.58)	4.54 (0.62)
	95% CI for mean	4.68-5.01	4.47-4.84	4.28-4.8
Platelets ×10³/mm³	Median (IQR)	248.5 (155)	283 (159)	378 (148)
	Mean (± SD)	260.2 (101)	272.2 (105)	356.3 (145)
	95% CI for mean	216.5-303.8	216-328	244-468

Post hoc test mean values of immuno-hematological parameters of CL patients

The treatment response was assessed by comparing cellular mean values at baseline and during the subsequent assessments at T1 and T2. Notably, the decline in WBC values from Time Zero (T0) was significant when comparing T0 to T1 ($p<0.05$), and a similar significant decline was observed from T0 to T2 ($p<0.05$). Furthermore, the lymphocyte counts showed a marked reduction between T0 and T1, as well as T0 and T2 ($p<0.05$ for both comparisons). The reduction in hemoglobin levels was also statistically significant when comparing T0 to T2 ($p<0.05$). Post hoc analyses highlighted that the reduction in WBCs was more pronounced after one month than at two weeks ($p=0.006$ versus $p=0.039$), while lymphocyte reductions were significant at one month ($p=0.001$) and two weeks ($p=0.002$). These results clearly demonstrate substantial reductions in WBC, lymphocyte, and hemoglobin levels throughout the treatment regimen, particularly evident immediately following the initiation of treatment (Table 3).

Table 3. Post hoc test of variables at different time and between groups.

Variables	Measurement Between Different Time	Mean Difference	Standard Error	Significance
WBC	T0 to T1	0.14636	0.05825	0.039
	T0 to T2	0.22072	0.06965	0.006
	T1 to T2	0.07437	0.07541	0.977
Lymphocytes	T0 to T1	0.35322	0.10145	0.002
	T0 to T2	0.45873	0.12318	0.001
	T1 to T2	0.10551	0.13302	1
Granulocytes	T0 to T1	0.36453	0.45605	1

	T0 to T2	0.93605	0.52977	0.243
	T1 to T2	0.57153	0.57539	0.971
Hemoglobin	T0 to T1	0.05631	0.02366	0.056
	T0 to T2	0.6044	0.02801	0.017
	T1 to T2	0.00808	0.03043	1
RBC	T0 to T1	0.03971	0.02717	0.43
	T0 to T2	0.06607	0.03168	0.117
	T1 to T2	0.02637	0.03393	1
Platelets	T0 to T1	-0.1713	0.25262	1
	T0 to T2	-0.4468	0.30511	0.45
	T1 to T2	-0.2755	0.32334	1

Discussion

In our study, we examined the clinical profiles of Cutaneous Leishmaniasis (CL) patients receiving Sodium Stibo Gluconate (SSG) treatment over a month. In contrast, a three-year longitudinal study involving 96 CL patients reported a median disease onset of 8 months. Additionally, research at Boru Meda Hospital, Ethiopia, indicated that most patients sought treatment after 13 months - 24 months (49.4%). In the study at Boru Meda, when patients first diagnosed 16 (39%) of them had a parasitic load of +1 while in Boru Meda it was 10 (13.9%). Traditional practice was interestingly higher in our study (65.6%). Similarly a study conducted in Boru Meda Hospital, Ethiopia, showed that 74(71%) of the patients were practiced traditional medicine. In our study, although different clinical forms were reported, their burden varies, the highest form was MCL type 62.6% likewise in, MCL was 66.3% [7-9].

In our study, the White Blood Cell (WBC) count significantly decreased during CL treatment. The baseline median value at T0 (before treatment initiation) was 6.09 $mm^3 \times 10^3/mm^3$, dropping to 5.3 $mm^3 \times 10^3/mm^3$ at the end of treatment. In contrast, other study showed, from a healthy individuals a median of WBC count, of 6.78 $mm^3 \times 10^3/mm^3$. Lower white blood cell counts in CL-infected individuals post-treatment suggest that treatment may not restore these levels. A Turkish study found significant reductions in WBC counts in treated patients compared to the control group, highlighting medication efficacy. Like our study, it is evident that treating of CL might challenge and negatively affect the immune-hematological parameters [10,11].

The median lymphocyte count decreased significantly from 2.3 $\times 10^3$ at pretreatment (T0) to 1.5×10^3 post-treatment (T2). Another study on CL, which examined the effect of localized heat and systemic antimonial therapy, found that a decline in cellular populations serves as a healing indicator. They concluded that healing is a dynamic process that modifies circulating lymphocyte populations, including T, NK, and NKT-like cells, with both local and systemic treatments leading to similar changes in frequency and quality [12].

The lymphocyte distribution, including T cells, B cells, NKT-like, and NK cells, remained stable from pre-treatment to the first ten days. However, post-treatment results showed a significant decrease in circulating T cells (73% pre *vs*. 63% post; p<0.0001) and an increase in NK cells (8% pre *vs*. 12% post; p=0.0005).

Changes in these cell populations were observed in both treatment options, heat and systemic SSG, affecting T cells, B cells, NK cells, and NKT-like cells. The reduction in cell numbers post-CL treatment requires further investigation to determine whether it indicates healing or disease progression. Consistent with our findings in the Turkish CL patient cohort, lymphocyte counts were significantly decreased following treatment.

Research has shown that CL-infected patient's exhibit increased cell activation and higher lymphocyte counts. A Sudanese case-control study confirmed this significant elevation in lymphocyte numbers among affected individuals, compared from the controls. Likewise, it is also supported by a study in Iran, both sexes of CL patients showed an increase of WBC and lymphocyte count compared from the controls. Our study observed significant reductions from baseline during treatment, although we did not include control comparisons. These changes might result from medication side effects rather than genuine improvement, as we did not see the expected increase in cell count post-treatment [13,14].

Different from other cellular profile of CL patients, the platelet number increased from pretreatment to post treatment. In agreement with our study, in Sudan, platelet counts increased in post-treatment, unlike other cellular profiles. This notable rise needs further investigation to answer the dilemma, hence in related studies it is shown that, a decreased platelet counts in post-treatment with SSG, highlighting the need for deeper exploration into these contrasting findings.

In our study, the median value of RBC before treatment initiation was 4.8 $mm^3 \times 10^6/mm^3$. Respective to this, other studies that compare among healthy groups of RBC the 95th percentile range was 3.93 mm^3 - 6.1 $mm^3 \times 10^6$ cells/mm^3. Interestingly, it was also shown that Leishmania parasite facilitated the infected macrophages to phagocytose of more RBCs, possibly to acquire heme from the Hb present in erythrocytes. In our study, hemoglobin levels remained consistent around 14 g/dl at various time points, both pre- and post-treatment. In Sudan, no significant difference in hemoglobin levels was observed between the CL cases and control group. This suggests that the Leishmania parasite or its medications did not impact abundance, while another study indicated that hemoglobin levels in CL patients were lower than in healthy individuals. Although we did not compare control group, a case control study in Iraq the hemoglobin concentration showed that, in cases of CL, a significant decreased in both sex than the control groups. Based on this and previous findings, more research required to answer the relationship between hemoglobin and CL, cellular count and treatment for the disease.

In this study, CL patients showed nearly normal baseline cellular counts, which significantly decreased post-SSG treatment (p<0.05). This suggests SSG may negatively impact cell proliferation or lifespan. Additionally, SSG affects host macrophages and parasites, indicating potential adverse effects on cellular dynamics in CL patients over time [15].

A reduction in WBCs and immune components increases infection risk and hinders parasite clearance in leishmaniasis, allowing prolonged parasite survival post-treatment, despite the absence of complete sterilization. Neutrophils, the first cells to encounter Leishmania, play a crucial role in eliminating amastigotes within macrophages. They communicate primarily through soluble factors and can produce TNF-α. Adding anti-TNF-α to

cultures diminished amastigote killing by approximately 30%, highlighting TNF-α's importance in this process. So, a decrease of cells involved in innate immunity aggravates the disease and might lead to a cause for higher chance of relapse [16].

Comparing VL cases on treatment and their cellular response showed a different pattern from we observed in CL, in VL patients having HIV or negative of HIV in both condition the cellular count of WBC showed increment following treatment. Leishmania is an intracellular parasite and its infection can lead to reduced cell counts. Treatment for Visceral Leishmaniasis (VL) often improves cellular counts, whereas CL shows limited improvement. This discrepancy may relate to the parasite's nature, treatment targets, and the effectiveness of medications used. In contrast to previous studies linking low potassium levels to anemia and affected hematological profiles before treatment, our study found that anemia was not an issue for CL patients either before or after treatment. This phenomenon might be explained by the difference in target organ being infested by the parasite. This might give an insight, VL might make the patients more anemic compared to CL. This concept also supported by a study conducted in University of Gondar Hospital, Ethiopia, In VL patients, hemoglobin levels average 8.69 ± 2.12. Research shows Leishmania is heme-auxotrophic, acquiring heme from hosts via a specific receptor. It internalizes hemoglobin through clathrin-mediated endocytosis, directing it to lysosomes using Rab5 and Rab7 pathways for degradation to produce necessary intracellular heme, Implies that, following Leishmania infection anemia could be the expected pathology, although in our case, CL study, it was not a problem.

Unlike our CL study showing decreased cellular profiles, treatment usually result seen improvement in immune-hematological profiles in different diseases such as HIV, malaria and VL SSG treatment for CL reduces circulating cell numbers by days 14 and 30, posing toxicity risks. Some drugs negatively affect immuno-hematological profiles, hindering recovery and potentially exposing patients to other diseases, significantly impacting their quality of life [17-22].

Conclusion

Three clinical forms of Cutaneous Leishmaniasis (CL) were noted, and traditional medicine was commonly used before seeking modern treatment. The absolute cell count in CL patients decreased during treatment, potentially linked to the effects of Sodium Stibo Gluconate (SSG). These cellular changes may contribute to relapse and prolonged healing times for lesions.

Recommendation

The program that deals with CL should consider other effective medication and supplements that boost immunity and foster cellular proliferation. A larger scale study is required to understand the effect of SSG treatment.

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Conflict of Interest

No conflict of interest declared from the author's.

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References

1. Da Silva Santos, Claire, and Cláudia Ida Brodskyn. "The role of CD4 and CD8 T cells in human cutaneous leishmaniasis." *Front Public Health* 2 (2014): 165.
2. McConville, Malcolm J., and Thomas Naderer. "Metabolic pathways required for the intracellular survival of Leishmania." *Annu Rev Microbiol* 65.1 (2011): 543-561.
3. Bogdan, Christian. "Leishmaniasis in rheumatology, haematology and oncology: epidemiological, immunological and clinical aspects and caveats." *Ann Rheum Dis 71. Suppl* 2 (2012): i60-i66.
4. Ansari, Irshad, Rituparna Basak, and Amitabha Mukhopadhyay. "Hemoglobin endocytosis and intracellular trafficking: a novel way of heme acquisition by Leishmania." *Pathogens* 11.5 (2022): 585.
5. Gashaw, Bizuayehu, et al. "Immuno-hematological profiles of Ethiopian cutaneous leishmaniasis patients before and during treatment with sodium stibogluconate."
6. Van Henten, Saskia, et al. "Treatment of cutaneous leishmaniasis with sodium stibogluconate and allopurinol in a routine setting in Ethiopia: clinical and patient-reported outcomes and operational challenges." *Trop Med Infect Dis* 8.8 (2023): 414.
7. Ademe, Muluneh, et al. "Hematological and clinical features associated with initial poor treatment outcomes in visceral leishmaniasis patients with and without HIV coinfection in Gondar, northwest Ethiopia." *Trop Med Infect Dis* 8.1 (2023): 36.
8. Shiferaw, Elias, et al. "Hematological profiles of visceral leishmaniasis patients before and after treatment of anti-leishmanial drugs at University of Gondar Hospital; Leishmania Research and Treatment Center Northwest, *Ethiopia." BMC Infect Dis*. 21 (2021): 1-7.
9. Tilahun Zewdu, Feleke, et al. "Effectiveness of intralesional sodium stibogluconate for the treatment of localized cutaneous leishmaniasis at Boru Meda general hospital, Amhara, Ethiopia: Pragmatic trial." *PLoS Negl Trop Dis* 16.9 (2022): e0010578.
10. Mulu, Wondemagegn, et al. "Haematological and CD4+ T cells reference ranges in healthy adult populations in Gojjam zones in Amhara region, Ethiopia." *PloS one* 12.7 (2017): e0181268.
11. Sula, Bilal, and Recep Tekin. "Use of hematological parameters in evaluation of treatment efficacy in cutaneous leishmaniasis." *J Microbiol Infect Dis* 5.4 (2015): 167-172.
12. Lakhal-Naouar, Ines, et al. "The immunology of a healing response in cutaneous leishmaniasis treated with localized heat or systemic antimonial therapy." *PLoS Negl Trop Dis* 9.10 (2015): e0004178.
13. Ma, Mokhtar, Dawelbiet A. Yahia, and Mustafa H. Ibrahim. "Evaluation of Hematological Findings among Patients with Cutaneous Leishmaniasis."
14. AL-Hoot, A., and S. A. Taha. "EFFECT OF CUTANEOUS LEISHMANIASIS ON SOME HAEMATOLOGICAL AND IMMUNOLOGICAL PARAMETERS IN PATIENTS FROM AREAS OF NORTH BAGHDAD/IRAQ." *Bull Fac Sci Zagazig Univ.* 2017.1 (2017): 354-366.
15. Mcgwire, B. Satoskar, and A. R. Satoskar. "Leishmaniasis: clinical syndromes and treatment." *QJM: Int J Med* 107.1 (2014): 7-14.
16. Carmo, Érico Vinícius de Souza, Simone Katz, and Clara Lúcia Barbiéri. "Neutrophils reduce the parasite burden in Leishmania (Leishmania) amazonensis-infected macrophages." *PloS one* 5.11 (2010): e13815.

17. Agrawal, Y., et al. "Hematological profile in visceral leishmaniasis." *Int J Infect Microbiol* 2.2 (2013): 39-44.
18. Ashenafi, Girma, et al. "Immunohematological Outcome Among Adult HIV Patients Taking Highly Active Antiretroviral Therapy for at Least Six Months in Yabelo Hospital, Borana, Ethiopia." *J Blood Med* (2023): 543-554.
19. Kayode, E. M., et al. "Assessment of the effect of anti-retroviral therapy on haematological parameters in HIV positive individuals in Zaria." *J AIDS HIV Res* 12.2 (2020): 17-23.
20. Mitra, J., and Sandeep M. Horo. "Analysis of haematological profile in HIV positive patients before and after antiretroviral therapy." *Int J Health Sci Res* 5.11 (2015): 18-24.
21. Pinedo-Cancino, Viviana, et al. "Hematological profiles of malaria-infected patients in an endemic area of Peru." *Rev Peru Med Exp Salud Pública* 39 (2022): 336-344.
22. Gashaw, Bizuayehu, et al. "Immuno-hematological profiles of Ethiopian cutaneous leishmaniasis patients before and during treatment with sodium stibogluconate."

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