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ORIGINAL ARTICLE

Correlation Between Infection Severity and Immunological Biomarkers in Patients with *Entamoeba histolytica*

Ali Mohammed Abed[1*], Mohammed Abbas Saab[2], Al-Shaima M Jasim[1], Haneen Khalid Naji Al-Samarrai[3]

[1]*Department of Biology, College of Sciences, Tikrit University, Tikrit, Iraq*
[2]*Ministry of Education / Anbar Education Directorate, Iraq*
[3]*Department of Pathological Analysis, College of Applied Sciences, University of Samarra, Samarra, Iraq*

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* *Corresponding author.*
Ali Mohammed Abed
a-m.abdnasir@tu.edu.iq

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ABSTRACT

Introduction: Amoebiasis is the third most prevalent parasite cause of morbidity and death, especially in nations with unsanitary conditions in Africa, India, and Central and South America. The current study was conducted to evaluate values of immunological parameters, hepcidin, ferritin, hematological indicators in patients with *Entamoeba histolytica*. **Materials and Methods:** The study included a total of 90 participants, that divided into 2 groups as 30 control and 60 patients infected with *E. histolytica*, which sub-divided according to severity into moderate and sever, each of them with 30 patients. The age range for both males and females was between 1 and > 65 years. All participants recruited between 4/1/2025 to 1/10/2025 were taken from people with diarrhea from Ameriyat Al-Sumoud district, Ameriyat General Hospital and outpatient clinics, in Anbar city. **Results:** The present study showed that IL-6 increased from 4.40 ± 0.82 in healthy individuals to 24.09 ± 5.10 in severe cases, and IL-10 increased from 6.51 ± 1.47 to 22.53 ± 4.50. In contrast, hepcidin levels decreased significantly with increasing infection severity, decreasing from 5.03 ± 1.32 g/dL in the control group to 0.88 ± 0.44 g/dL in severe cases. Hemoglobin levels decreased from 12.03 ± 1.08 g/dL in the control group to 9.20 ± 0.82 g/dL in severe cases. The MCV, MCH, and MCHC values also decreased, while RDW-SD was significantly elevated in patients, particularly in severe cases. Platelet count showed a significant increase with infection severity, rising from 306.9 ± 88.2 to 666.8 ± 112.3 × 10^3/µL. Ferritin levels were also reduced in patients compared to control, particularly in severe cases, decreasing from 105.18 ± 55.4 to 7.48 ± 5.1 ng/mL. **Conclusion:** According to the results of this investigation, hematological parameters, interleukin-6 (IL-6), interleukin-10 (IL-10), and hepcidin are all potential biomarkers for the detection of the *E. histolytica* parasite.

Keywords: *E. histolytica*; Immunological biomarkers; Hematological parameters

INTRODUCTION

According to WHO (2020)[1], amoebiasis is the third most prevalent parasite cause of morbidity and death, especially in nations with unsanitary conditions in Africa, India, and Central and South America. Just 10–20% of those infected with *E. histolytica* exhibit symptoms. Weight loss, cramping in the abdomen, pain, and watery or bloody diarrhea are symptoms of the disease. Fever and right upper quadrant abdominal pain may be signs of hepatic involvement (liver abscess)[2, 3].

The pathogenic protozoan parasite *Entamoeba histolytica* is a type of disease-causing protozoan. According to a

2018 report by Sauvey *et al.*[4], this parasite causes approximately 50 million infections and 70,000 deaths worldwide each year. It has two core stages in its life cycle: the trophozoite and the cyst. It can invade the human body via contaminated food and water, first colonizing the intestinal tract, and is capable of further invading the liver, lungs, and brain. Ninety percent of infected individuals are asymptomatic, but the infection can trigger severe conditions such as bloody diarrhea. Relevant clinical conclusions are cited from studies by Jasni *et al.,* (2022) and Jiang *et al.,* (2024)[5, 6].

Entamoeba histolytica is the causative agent of amebiasis, an intestinal parasitic illness. Humans can contract the single-celled protozoan *Entamoeba histolytica* through ingesting tainted food or water. Loose poops, cramps, and pain in the abdomen are signs of an amoebic infection. However, the majority of amebiasis patients will not have any significant symptoms. In tropical nations with lax public health measures, amoebae infections are prevalent[7]. This study first clarifies that protozoan trophozoites in the colon hematogenously disseminate to the liver via the portal circulation, and trigger hepatocyte injury through three types of mechanisms: parasite-induced cytotoxicity, inflammatory mediators, and host immune responses. This pathogenic pathway is supported by citations of Kumar *et al.* (2024)[8] and Sellau *et al.* (2021)[9]. The study further cites Usuda *et al.* (2022)[10] to note that the heterogeneity of subsequent liver biochemical changes is determined by four core factors.

When a host contracts an infection with *Entamoeba histolytica* (*E. histolytica*), it rapidly initiates a multi-dimensional normal immune response. Drawing on the set of preliminary pathogen-blocking defense mechanisms outlined in Uribe-Querol & Rosales (2020)[11] — which include lymphocytes, mucus secreted by the mucosa of the skeletal system, intestinal peristalsis, and the acidic environment of the stomach — this study proposes that cell-mediated immune responses are the core host defense mechanism against this pathogen. The Toll-like receptor (TLR)-2/4 NFKB plays a role in the initial stage of infection through the interaction of the carbohydrate domain of Gal/GalNAc lectin with intestinal epithelial cells. This interaction results in the generation of inflammatory cytokines such as IL-1B, IL-6, IL-8, IL-12, IL-17, IFN-Y, and TNF-α [12, 13]. host tolerance to the invading trophozoites is maintained by many host variables. IL 10 supports mucosal barrier integrity. IL 10 defective mice were significantly sensitive to intestinal invasion in an amebic colitis model[14]. The liver-expressed antimicrobial peptide hepcidin is secreted mainly by hepatocytes near the portal veins (delivering dietary iron) and by Kupffer cells (sensing bacteria and recycling erythrocytes). In addition, a tiny quantity of hepcidin is produced by both adipocytes and macrophages[15]. Hence, present investigation was carried out for evaluation of values of immunological indices, hepcidin, ferritin, hematological indicators in patients with *Entamoeba histolytica*.

MATERIALS AND METHODS

Sample collection

The study included a total of 90 participants, that were divided into 2 groups as 30 control and 60 patients infected with *E. histolytica*, which sub-divided according to severity into moderate and sever, each of them with 30 patients. The mean age in the control group was 31.1 ± 20.4 years, while the mean age in the moderate anemia group was 26.8 ± 20.5 years, and the severe anemia group had a mean age of 31.2 ± 19.5 years. All participants were recruited between 4/1/2025 to 1/10/2025 were taken from people with diarrhea from Ameriyat Al-Sumoud district, Ameriyat General Hospital and outpatient clinics, in Anbar city.

Microscopic examination

Stool samples were obtained using a sterile container. Fresh samples were then analyzed under a light microscope at a high magnification of 40X. A small volume (1-3 ml) of feces. 4-6 ml of venous blood samples were collected by venipuncture. The blood samples were quickly transferred into containers containing EDTA for CBC analysis after sampling. For the serum biochemistry study, another part was moved into tubes that did not contain anticoagulant. Serum was extracted from blood samples centrifuged at 5,000 rpm for 5 minutes at room temperature in tubes that did not contain anticoagulant.

Blood and biochemical tests

Sixty people were diagnosed with the parasite, exhibiting indications of infection. Blood was obtained for the execution of hematological and biochemical analyses. This study conducted two types of medical tests. The seven indicators for hematological complete blood count (CBC) analysis were detected using the pocH-100i® fully automatic hematology analyzer manufactured by Sysmex Corporation, based in Kobe, Japan. The biochemical tests covered two parameters: alkaline phosphatase and ferritin.

Assessment of the IL-6, IL-10, and Hepcidin

The concentration of IL-6, IL-10, and Hepcidin was quantified via ELISA. The plate has been pre-treated with a human anti- (IL-6, IL-10, and Hepcidin) antibody. In this experiment, three target molecules IL-6, IL-10, and Hepcidin were first introduced into biological samples. After immune complexes were coated using the corresponding biotinylated human-derived antibody conjugates, the substrate was added, followed by the addition of an acidic stop solution. Absorbance was then

detected at a wavelength of 450 nm to complete the quantitative detection of the target proteins.

Assessment of ferritin

Ferritin levels were measured using an automatic biochemistry analyzer within the scope of serum biochemistry.

Statistical analysis

Analyses for this study were completed using IBM SPSS Statistics 26.0, while GraphPad Prism 8 was used for data visualization and result validation. Continuous variables are presented as mean ± standard deviation, and categorical variables are summarized by frequency and percentage (%). Comparisons among the three study groups (controls, moderate anemia, and severe anemia) were performed using one-way analysis of variance (ANOVA) for continuous variables. Upon obtaining statistically significant results, Bonferroni post-hoc test was applied to determine pairwise differences between groups.

Categorical variables, including gender and age group distributions, were analyzed using the Chi-square (χ^2) test, with Fisher's Exact test applied when the expected cell counts were less than 5. Correlation between biomarkers and hematological parameters was assessed using Spearman's rank correlation coefficient (r), to evaluate the strength and direction of associations. GraphPad Prism was specifically utilized for generating graphs, including bar charts and correlation plots, as well as for visual interpretation of statistical findings. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The total sample of 90 participants was divided equally between the control group and the two groups of parasitic infection depending on symptoms as moderate and severe. Each group comprised 30 individuals, representing 33.3% of the total sample.

A significant increase in IL-6 and IL-10 levels was observed in patients compared to the control group. IL-6 increased from 4.40 ± 0.82 in healthy individuals to 24.09 ± 5.10 in severe cases, and IL-10 increased from 6.51 ± 1.47 to 22.53 ± 4.50. In contrast, hepcidin levels decreased significantly with increasing infection severity, decreasing from 5.03 ± 1.32 g/dL in the control group to 0.88 ± 0.44 g/dL in severe cases. Hb, PCV, and RBC levels decreasing significantly with infection severity. Hemoglobin levels decreased from 12.03 ± 1.08 g/dL in the control group to 9.20 ± 0.82 g/dL in severe cases. The MCV, MCH, and MCHC values also decreased RDW-SD was significantly elevated in patients, particularly in severe cases.

PLT showed a significant increase with infection severity, rising from 306.9 ± 88.2 to 666.8 ± 112.3 × 10^3/µL. Ferritin level also reduced in patients compared to control, particularly in severe cases, decreasing from 105.18 ± 55.4 to 7.48 ± 5.1 ng/mL. In contrast, non-significant difference between the groups (P = 0.631), regarding ages as shown in Table. 1.

The inflammatory cytokines IL-6 and IL-10 showed highly significant differences between all groups (P < 0.001), including the comparison between moderate and severe cases. Hepcidin also showed a significant decrease between all groups, even between moderate and severe cases (P = 0.0002).

Table 1: Comparison level of immunological, hematological, biochemical between study groups

Variable	Controls (mean±SD)	Moderate (mean±SD)	Severe (mean±SD)	p-value	Sig.
IL-6	4.40 ± 0.82	17.07 ± 3.42	24.09 ± 5.10	<0.001	***
IL-10	6.51 ± 1.47	17.99 ± 4.12	22.53 ± 4.50	<0.001	***
Hepcidin	5.03 ± 1.32	1.25 ± 0.62	0.88 ± 0.44	<0.001	***
HGB (g/dL)	12.03 ± 1.08	9.80 ± 0.99	9.20 ± 0.82	<0.001	***
HCT (%)	40.50 ± 3.12	33.37 ± 2.50	31.43 ± 2.30	<0.001	***
RBCs (x10^6/µL)	4.93 ± 0.48	3.70 ± 0.55	3.14 ± 0.44	<0.001	***
MCV (fL)	89.78 ± 5.20	78.23 ± 4.10	71.89 ± 3.80	<0.001	***
MCHC (g/dL)	34.45 ± 1.20	30.87 ± 1.40	30.38 ± 1.30	<0.001	***
MCH (pg)	29.85 ± 2.10	24.40 ± 1.80	23.71 ± 1.50	<0.001	***
RDW-SD	46.21 ± 4.20	58.13 ± 5.50	63.75 ± 6.10	<0.001	***
PLT (x10^3/µL)	306.9 ± 88.2	528.5 ± 95.4	666.8 ± 112.3	<0.001	***
Ferritin (ng/mL)	105.18 ± 55.4	10.71 ± 8.2	7.48 ± 5.1	<0.001	***
Age (years)	31.12 ± 20.1	26.82 ± 18.5	31.20 ± 21.4	0.631	ns

*** p < 0.001· ** p < 0.01 · * p < 0.05 · ns = not significant

Table 2: Post-Hoc Pairwise Comparisons (Bonferroni-Corrected) of immunological, hematological, biochemical between study groups

Variable	Controls vs Moderate	Controls vs Severe	Moderate vs Severe
IL-6	*** < 0.001	*** < 0.001	*** < 0.001
IL-10	*** < 0.001	*** < 0.001	*** < 0.001
Hepcidin	*** < 0.001	*** < 0.001	** p = 0.0002
HGB	*** < 0.001	*** < 0.001	ns (p = 0.601)
HCT	*** < 0.001	*** < 0.001	ns (p = 0.601)
RBCs	*** < 0.001	*** < 0.001	** p = 0.003
MCV	*** < 0.001	*** < 0.001	*** < 0.001
MCHC	*** < 0.001	*** < 0.001	ns (p = 0.569)
MCH	*** < 0.001	*** < 0.001	ns (p = 0.055)
RDW-SD	*** < 0.001	*** < 0.001	*** < 0.001
PLT	*** < 0.001	*** < 0.001	*** < 0.001
FERRITIN	*** < 0.001	*** < 0.001	ns (p = 0.293)

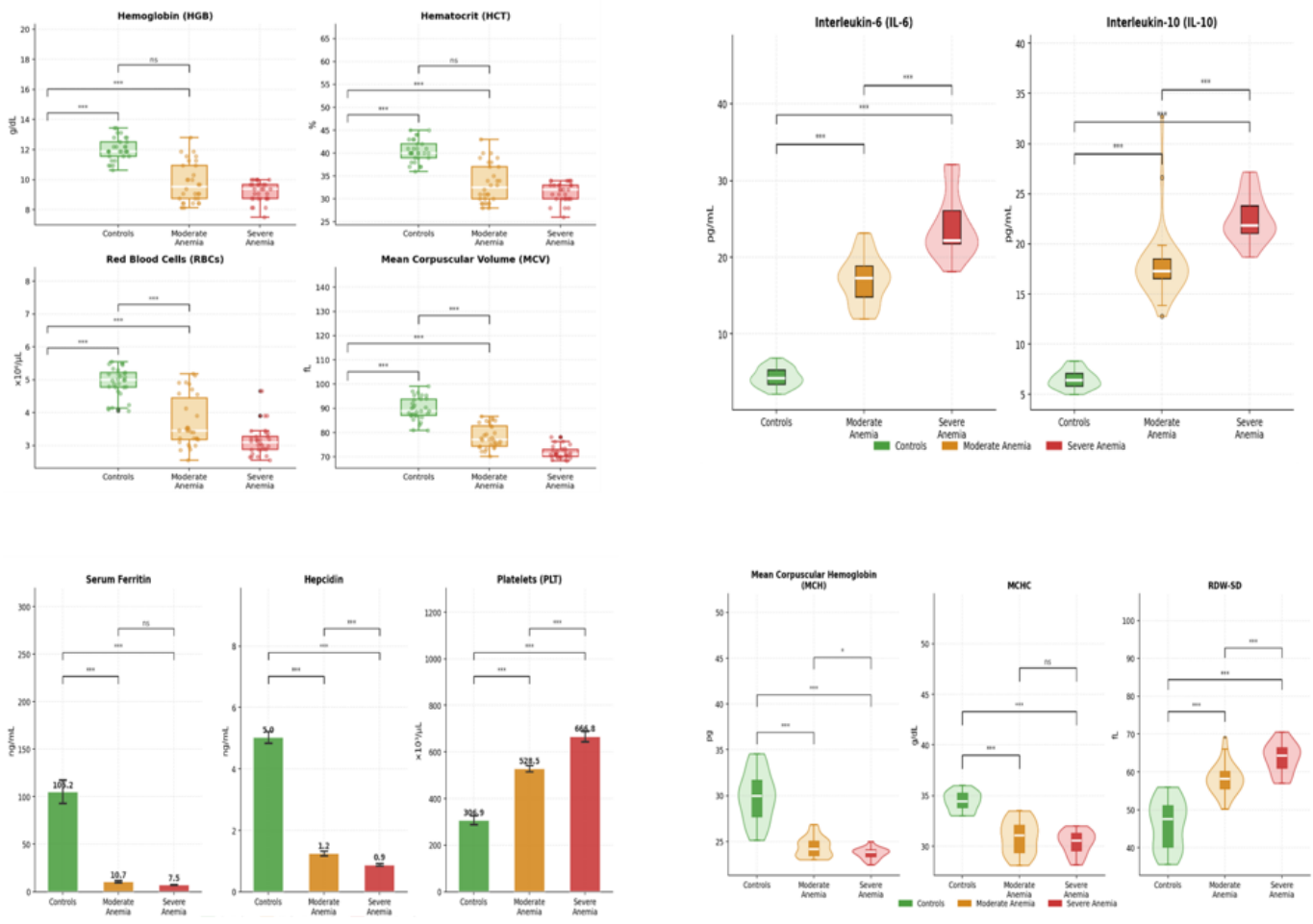

Fig. 1: Post-Hoc Pairwise Comparisons (Bonferroni-Corrected) of immunological, hematological, biochemical between study groups

Regarding Ferritin, Hb and PCV values showed significant differences between the control group and both patient groups, while no significant differences were found between moderate and severe cases. RBCs also showed a significant difference between moderate and severe cases. MCV showed highly significant differences

between all groups. In contrast, MCHC and MCH values did not show significant differences between moderate and severe cases. RDW-SD also showed highly significant differences between all groups. For PLT highly significant differences were also observed between all groups as shown in Table. 2 and Fig. 1.

Table 3: Spearman Rank Correlation of immunological, hematological, biochemical between study groups

Biomarker pair	r	p-value	Direction
IL-6 vs IL-10	0.839	<0.001	Positive
IL-6 vs PLT	0.815	<0.001	Positive
Ferritin vs MCV	0.816	<0.001	Positive
MCV vs RBCs	0.791	<0.001	Positive
HGB vs RBCs	0.748	<0.001	Positive
HGB vs Ferritin	0.762	<0.001	Positive
Hepcidin vs PLT	-0.798	<0.001	Negative
IL-6 vs MCV	-0.797	<0.001	Negative
IL-6 vs Hepcidin	-0.765	<0.001	Negative
IL-10 vs Hepcidin	-0.764	<0.001	Negative

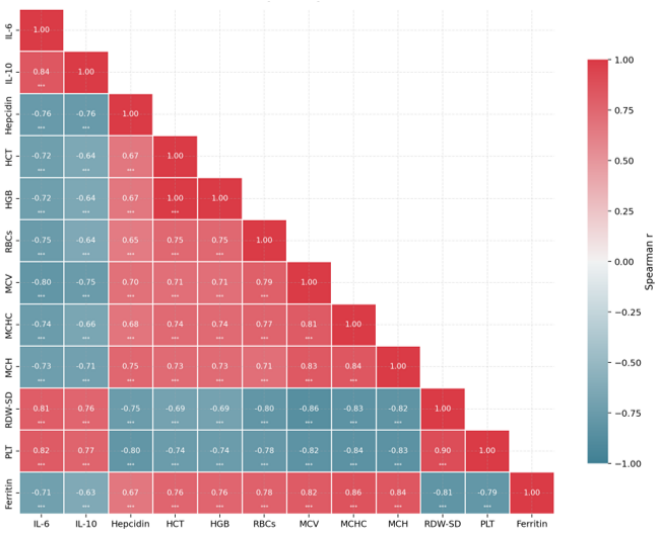

Fig. 2: Spearman Rank Correlation of immunological, hematological, biochemical between study groups

Diverging color scale from r = -1 (blue) to r = +1 (red). *** p < 0.001.

The correlation analysis revealed strong and statistically significant relationships between immunological and hematological markers in patients infected with the parasite. All correlation values were highly significant (P < 0.001), indicating a clear link between inflammation severity, iron imbalance, and hematological changes resulting from the parasitic infection. The results showed a very strong positive correlation between IL-6 and IL-10 (r = 0.839), IL-6 and PLT (r = 0.815), ferritin and MCV (r = 0.816), MCV with RBCs (r = 0.791), HGB and RBCs (r = 0.748), and HGB with ferritin (r = 0.762). In contrast, some variables showed strong inverse relationships. A strong negative correlation was found between Hepcidin and PLT (r = -0.798), IL-6 and MCV (r = -0.797), IL-6 and Hepcidin (r = -0.765), as well as between IL-10 and Hepcidin (r = -0.764) as shown in Table. 3 and Fig. 2.

DISCUSSION

The current investigation found that patients with *E. histolytica* had higher levels of IL-6 and IL-10, which were correlated with severity. This study supports the findings of[16], which demonstrated elevated IL-6 in *E. histolytica* patients. When compared to healthy controls, individuals with amebic liver abscesses had much greater levels of the cytokine IL-6[17]. Through IL-1β and STAT3, IL-6 contributes to the liver's synthesis of the acute phase reactant C-reactive protein (CRP)[18]. Additionally, IL-6 is a peripheral indicator of acute inflammation in a variety of clinical conditions[17]. It was most recently demonstrated that *E. histolytica* has a humanlike macrophage migration inhibitory factor (EhMIF) that stimulates IL-6 synthesis, which may further contribute to IL-6 production during invasive amebiasis[19]. IL-6 deficiency enhanced the risk of amebic liver abscess in a mouse model of amebiasis, indicating an important function for IL-6 in the inflammatory processes caused by *E. histolytica*[20].

This finding is in agreement with that of Ngobeni *et al.* (2022)[21], who discovered that malnutrition reduces the production of cytokines and the proper response of lymphocytes to these signals. When *E. histolytica* invades liver tissue, the immune system goes into anti-inflammatory mode. IL-10 has the ability to block the production of proinflammatory cytokines by cells such regulatory T-cells and macrophages, including IFN-γ, IL-2, IL3, TNF-α, and GM-CSF. In addition to its powerful antigen-presenting cell suppression capabilities, it acts as a stimulant to specific T cells (Th2) and mast cells, promotes B cell maturation and antibody production, and more[22].

Due to the high density of this protozoan, nutrients needed to produce blood components are mal-absorbed[23]. These results are consistent with those of Ahmed and Al-Naqeeb (2026)[24], who discovered that people with specific

intestinal parasite infections frequently experienced anemia. These results are consistent with those of Ahmed and Al-Naqeeb (2026)[24], who discovered that people with specific intestinal parasite infections frequently experienced anemia. Ferritin is considered an early and highly specific marker since serum ferritin is a measure of body iron reserves and is used to detect iron insufficiency in the absence of concomitant diseases. Children infected with *E. histolytica* likely have low ferritin levels because the parasite's trophozoite can use ferritin as an iron source[25]. It is known that the intestinal parasite *Entamoeba histolytica* requires iron for its metabolic processes. As a result, it makes use of the iron present in the liver and the lining of the large intestine, which is where the parasite first appears. According to research by Lopez-Soto *et al*. (2009)[25], *E. histolytica* uses ferritin as a crucial iron source during its trophozoite stage by attaching to it via certain proteins. The iron reserves of those infected with this parasite are significantly reduced as a result of this interaction.

The present study showed decreased level of hepcidin in parasitic infection, which agrees with the study of Abdullah *et al.*, (2025)[26]. Parasite protozoa require iron for survival and it is necessary for *E. histolytica* growth and enzymatic activities because iron enters the synthesis of parasite enzymes[27]. Infection with *Entamoeba histolytica* has been linked to increased levels of some biochemical indicators and changes in hepcidin. The study disagrees with the research of Abd & Al-Hadraawy (2023)[16], and demonstrates the increased hepcidin level in patients infected with *E. histolytica*. The present study also showed decrease PCV, Hb, and increased PLT. The study by Hussien & Obaid (2025)[28], showed increased level of platelets.

CONCLUSION

According to the results of this study, hematological parameters, interleukin-6 (IL-6), interleukin-10 (IL-10), and hepcidin were all positive for *E. coli. Entamoeba histolytica* are competency biomarkers for parasite detection.

DISCLOSURE

Conflict of Interest: The authors declare no conflict of interest with the study.

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