Toxoplasmosis in thalassemic iraqi patients: serological and hematological study

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Toxoplasmosis in thalassemic iraqi patients: serological and hematological study

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Abstract

Toxoplasmosis is a zoonotic parasitic disease with high prevalence, it causes by an obligate intracellular parasite *Toxoplasma gondii*. Thalassemia is a blood disturbance has undergone through families in which the body makes an atypical form or sufficient amount of hemoglobin. The condition results in great numbers of red blood cells being damaged which cause to anemia. Samples were collected during March to June 2022 from Al- Karama Teaching Hospital in Baghdad, Iraq.After doctors diagonsis, nacessary blood tests to deect thalassemia in a group of 165 thalassemic patients and 80 healthy controls. Serum specimens were investigated for Toxo IgM and IgG antibodies using immunochromatography test and chemiluminescent (CIMA) test, their age from 2-45 years. Results for immunochromatography test showed 44/165(26.67%) in thalassemic patients who have positive response for anti-*Toxo* IgG antibodies comparative with non- thalassemic control groups 33/80(41.25%) samples of have positive response for this test .The percentage infection with toxoplasmosis from thalassemia patients,60/165(36.36%) patients who have positive response for anti-*Toxoplasma* IgG antibodies as well as 25/80(31.25%) of non-thalassemic control group have positive response in chemiluminescent micro particle immunoassay(CMIA).However, result of CBC test showed that low significant levels in the group of thalassemic patients with toxoplasmosis with mean of Hb(8.286±0.128g/dl) ,MCV(62.027±2.146Fl) MCH(23.111±0.[illegible]pg) and MCHC (26.888±0.385 g/dl) respectively in comparison with control group. The purpose of this study was to identification the prevalence of *T. gondii*antibodies and hematological changes among thalassemic patients.

Keywords: Toxoplasmosis, Thalassemic, IgM, IgG, Hb and PCV

Introduction

The single-celled parasite *Toxoplasma gondii* is the cause of the toxoplasmosis infection. One of the most widespread parasite infections, it affects almost all warm-blooded creatures including humans and pets. During pregnancy, this parasite can be vertically passed to the fetus and the child may experience a wide range of clinical symptoms. It is an opportunistic pathogen in which the recurrence of the latent infection can cause death in congenitally infected fetuses, newborns, and immunocompromised patients [1-4]. *T. gondii* has three morphological forms, which are tachyzoites, bradyzoites and sporozoites [5]. The intestinal phase of the parasite's life cycle occurs in the small intestine of cats, while the extra intestinal phase affects all intermediate hosts [6]. A series of genetic illnesses known as thalassemia cause a lower rate of - or -chain synthesis which partially or totally suppresses the rate of hemoglobin synthesis [7]. Thalassemia comes in two varieties: alpha and beta. Beta thalassemia major is an inherited disorder that may affect general health, gene mutations that result in low level and/or malfunctioning globin protein respectively, are the root causes of these disorders, one of these proteins might occasionally not exist at all Carriers of alpha or beta thalassemia trait exhibit minor symptoms depending on how severe the disease is, the human beta globin (HBB) gene, which is located on

chromosome 11, regulates the form and functionality of hemoglobins, alpha thalassemia can lead tocomplications like hemolytic anemia or deadly hydrops fetalis [8-11].

Early infancy skeletal abnormalities one of the negative consequences of beta thalassemia major is hemolytic anemia, along with growth retardation. Children with this illness need frequent blood transfusions throughout their entire lives. Patients who need blood transfusions frequently suffer from iron overload, which can damage their liver or kidneys and cause other health problems. Thalassemic patients who received blood transfusion are susceptible to acquiring toxoplasmosis, so blood transfusion is a source of a number of infections in some cases if the donor is infected with some serious diseases, especially parasitic infections [12]. The target of the present study was to specify the prevalence of *T. gondii* antibodies in thalassemic Iraqi patients and estimate some hematological indicators among them.

Materials and Methods

Subjects

This study was included cases were collected during March to June 2022 from Al-Karama Teaching Hospital in Baghdad, Iraq. After doctor's diagnosis, necessary blood tests to detect thalassemia. A group of 165 thalassemic patients and 80 healthy controls, their age range from 2-45 years. Venous blood in the amount of 5 ml was taken from the sample. In order to separate the serum, three ml of the blood sample were immediately transferred to a gel tube and allowed to coagulate at room temperature (20–25°C) for 15 minutes, two ml of the blood sample were transferred to an EDTA-tube for haematological analysis.

Thalassemic diagnosis

Anti-coagulated blood samples were used to determine concentrations of red blood cells (RBC), Haemoglobin (Hb), pecked cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) by using CELL-DYN Ruby Haematology Analyzer system by the manufacturer Abbott.

T. gondii diagnosis

The procedures were carried out conferring to the kit manufacturer's protocol. *T.gondii* detected firstly by using *Toxoplasma* IgM/IgG antibody Immunochromatography rapid test kit (Qingdao Hightop Biotech Company, China). According to the manufactures protocol followed by measuring the levelsof IgM/IgG via using chemiluminescent microparticles immunoassay (CMIA) architect Toxo IgM/G kit (Abbott GmbH, Germany) depending to the manufacturer's instructions.

Statistical Analysis

The impact of various factors on research parameters was determined using the Statistical Analysis System-SAS (2018) application[13]. To statistically compare between means, the Least Significant Difference (LSD) test (Analysis of Variation, ANOVA) was employed. In this study, the significant (P0.01, P0.05) probability was found using the Chi-square test.

Results

Table 1 shown percentage of toxoplasmosis infection that 44/165 (26.67%) of the group of thalassemic patients hasseropositive response for anti-*Toxo IgG* antibodies, also 33/80 (41.25%) of the group of non-thalassemic control has seropositive response for anti-*Toxoplasma* IgG antibodies with significant differences were observed in this test among theresults (P≤0.01).

Table1. Immunochromatography Rapid test results of *Toxoplasma* IgM/IgG antibody in thalassemic and non-thalassemic groups.

Group name	Total No. of samples for each group	IgG	IgM	IgG and IgM	P-value
Thalassemic patients	165	26.67% 44	00.0% 0	0.60% 1	0.0001 **
Non-thalassemic control	80	41.25% 33	1.25% 1	2.5% 2	0.0001 **
P-value	---	0.078 NS	0.802 NS	0.711 NS	---

** (P≤0.01) highly significant.

Moreover, **table 2** shown percentages of toxoplasmosis infections that 60/165 (36.36%) of the group of thalassemic patients who has positive response for anti-*Toxoplasma* IgG antibodies well 25/80 (31.25%) of the group of non-thalassemic has positive response for the same antibody. Significant differences observed in this test among the results (P≤0.01)

Table2. Percentage of Toxoplasma IgM/IgG antibodies in thalassemic and non-thalassemic groups.

Group name	Total No. of samples for eachgroup	IgG	IgM	P-value
Thalassemia patients	165	36.36% (60)	0.0% (0)	0.0001 **
Non- thalassemia control	80	31.25% (25)	0.0% (0)	0.0001 **
P-value		0.0001 **	NS	

** (P≤0.01) highly significant.

Furthermore, **table 3** revealed that the group of thalassemic patients with toxoplasmosis has the highest level of IgG antibody 41.475±9.193 IU/mL according to CMIA followed by the group of non-thalassemic control positive which has the level of *Toxoplasma* IgG antibody 35.59±8.336 IU/mL. However, all groups were seronegative response for anti-*Toxoplasma* IgM antibody.

Table3. Values of Architect Toxo – IgG and Toxo - IgM assay IU/mL in studied groups.

Groups	NO	Mean ± SE UI/Ml IgG	Mean ± SE UI/Ml IgM
Thalassemic patients with toxoplasmosis	60	41.475±9.193	0.211± 0.098
Thalassemic patients	105	0.489±0.084	0.073±0.0022
Toxoplasmosis (control positive)	25	35.59±8.336	0.103±0.03
Healthy individuals (control negative)	55	0.5616±0.246	0.0422±0.004
LSD value		13.64 **	0.0662 *
P-value		0.0056	0.0278

- * (P≤0.05) significant, ** (P≤0.01) highly significant.

The **table 4** clarified that highly significantly decreases of RBC, Hb, PCV and MCH (2.572±0.062, 8.286±0.12, 26.674±0.348 and 23.111±0.327) respectively in the group of thalassemic patients with toxoplasmosis, while the results showed decreases of RBC, Hb, PCV and MCH (2.586±0.026, 8.134±0.53, 26.674±0.348 and 23.348±0.194) respectively in the group of thalassemic patients were observed (P≤0.01).

Table 4. Comparisons between thalassemic and non-thalassemic groups of hematological parameters values.

Groups	Mean ± SE					
	RBC	Hb	PCV	MCV	MCH	MCHC
Thalassemic patients withtoxoplasmosis	2.572± 0.062	8.286± 0.12	26.972± 0.523	62.027± 2.146	23.111± 0.327	26.888±0.385
Thalassemic patients	2.586± 0.026	8.134± 0.53	26.674± 0.348	66.5± 0.843	23.348± 0.194	26.542±0.236
Control positive (Toxoplasmosis)	4.106± 0.062	13.216 ±0.109	39.566± 0.334	90.014± 0.589	29.703± 0.118	33.206±0.099
Control negative (Healthy individuals)	5.134± 0.064	13.024 ±0.098	39.52± 0.255	93.846± 0.514	29.73± 0.109	33.65±0.108
LSD value	1.63 **	2.19 **	7.53 **	13.59 **	5.988 *	4.803b *
P-value	0.0056	0.0006	0.0022	0.0001	0.0289	0.0392

* (P≤0.05) significant, ** (P≤0.01) highly significant

The percentages of distribution of the analyzed groups according to age categories are shown in **tables 5** that clarified age range of 13–25 has a high percentage in all study groups 50.00%, 47.60% and 44.00% respectively in comparison with healthy control.

Table 5. Distribution of age characteristic in the studied group

Age range (Year)	Thalassemic patients with toxoplasmosis		Thalassemicpatients		Toxoplasmosis patients (controlpositive)		Healthy individuals (control negative)		P-value
	No/60	%	No/105	%	No/25	%	No/55	%	
2-12	25	41.60	46	43.80	6	24.00	29	52.70	

13– 25	30	50.00	50	47.60	11	44.00	20	36.40	0.0001 **
26– 38	4	6.70	8	7.70	4	16.00	4	7.30	
>39	1	1.70	1	0.90	4	16.00	2	3.60	
Mean ± SE	17.25± 8.40		17.25± 0.69		43.1 ± 2.90		32.76 ± 1.83		0.0001 **

** (P≤0.01) highly significant

The results in **table 6** demonstrated the gender of the thalassemic patients. Among 35/60 of thalassemic patients with toxoplasmosis (58.30%) were males and 25/60 (41.70%) were females, while the percentage of thalassemic patients was 57.10 % male and 42.90% female categories. Furthermore, percentage of healthy individuals was 58.20% male and 41.80%% female.

Table 6. Distribution of studied groups according to the gender characteristic.

Groups	Male No. (%)	Female No. (%)	P-value
Thalassemic patients with toxoplasmosis	35 (58.30%)	25(41.70%)	0.025 *
Thalassemic patients	60(57.10%)	45(42.90%)	0.077
Toxoplasmosis patients (control positive)	14(56.00%)	11(44.00%)	0.152
Healthy individuals (control negative)	32 (58.20%)	23(41.80%)	0.025 *
P-value	0.0001 **	0.0097 **	---

* (P≤0.05) significant, ** (P≤0.01) highly significant

Discussion

Toxoplasmosis has long been recognized as an opportunistic of illness in persons with impaired immune systems, blood transfusion infections are taken seriously, especially if they spread to people who receive blood transfusions frequently such as patients with thalassemia particularly in the acute stage, toxoplasmosis is thought to be a transfusion-transmissible infection among seropositive asymptomatic patients, it is normally asymptomatic in immunocompetent people, but it can cause substantial issues in immunocompromised people and can progress to a life-threatening infection [14-16].

In addition, the IgM/IgG antibodies immunochromatography rapid test is quick and simple utilized as a viable substitute screening tool for toxoplasmosis detection, results are acquired in 15 minutes without the need for equipment or experience and it has a good specificity, positive or negative results in this test is determined by a visual colorimetric measurement made with the unaided eye. As a result of this qualitative or semi quantitative choice, false positive and false negative issues are unavoidable [17,18].

Additionally, the innovative anti-*Toxoplasma* IgG/IgM chemiluminescent microparticle immunoassay (CMIA), afully automated method for evaluating the immunological status of the patients and ruling out either an acute or chronic infections, is used to identify *Toxoplasma*

antibodies. It is regarded as a straight forward, inexpensive method with good sensitivity and specificity for toxoplasmosis screening [19]. Blood transfusion is a source of a number of infections in some cases if the donor is infected with some serious diseases, especially viruses and parasites, in which the blood is the main way of transport if it is taken frominfected patients or contaminated from the environment or during the transfer. Acute parasitic infection in thalassemia patients can develop intoa chronic stage that causes disorders in patients [20,21].

Toxoplasmosis has long been recognized as an opportunistic illness in persons with immunocompromisedpatients. . It is a great importance, and that the disease does not show any clinical specific signs. It is also recognized as the third most common reason for AIDS patients to die, which makes it an important issue [22,23]. According to the findings of Hanifehpour *et al*. [23]. 55.31% of patients with thalassemia major and 37.02% of healthy individuals had anti-*Toxoplasma* IgG antibodies. Thalassemia patients may have greater anti-*Toxoplasma* IgG antibody titers than the control group because they are more likely to be at risk for *Toxoplasma* infection than healthy people because of frequent blood transfusions, thalassemic patients are to be compromised immune response against different type of infections, the reason for the differences in the results are not fully understood, but various factors such as environmental conditions, cultural habits, foods and safety level of the people against this parasite are the factors that can effect on the level of infection [24].

Karakas *et al*. [25]. revealed that 7 /36(19.4%) of patients with thalassemic major patients and 5/36 (14%) of healthy control have seroprevalence rate of anti-Toxo IgG, however anti-Toxo IgM shown in 2/36 (5.5%) in thalassemic major patients.

The above results of **table 4** may be attributed to the reduced beta globin chains in Hb molecules of thalassemic patientsas a result, the structural alterations in Hb molecules patients which lead to RBCs characterized by excess boundless globin protein in cell membranes, this makes them subject to damage by phagocytic cells in the bonemarrow, which could distinguish and damage abnormal cells leading to destruction of a great numbers of red blood cells through the process of erythropoiesis. Because thalassemia is a hereditary Hb synthesis defect thatcauses severe anemia in thalassemic patients, In the middle East and Mediterranean regions as well as more recently around the world [26]. Given the constant mobility of individuals to different parts of the world, particularly western countries, sickle cell- beta thalassemia (HbS/-thal) is a good example of a mixture of two common hereditary anemias [27].

Beta thalassemia major patients may develop per oxidative tissue harm from repeated blood transfusions due to secondary iron excess [28]. Patients' hemoglobin levels dropped significantly, when compared to the values observed in controls, indicating that they needed blood transfusions, which was the main cause of iron excess [29]. MCV and MCH are highly linked to hypochromic microcytic anemia. Study of Fadhil *et al* [30]. studied hematological parameters in thalassemic patients which noticed that Hb decreased in thalassemic patients (7.05± 1.43) g/dL in comparison with control groups (13.19± 0.95) g/dL.

The above of **table 5** results attributed due to the patient who is up to 20 years is exposed to many complications, the most important of which is the increase iron overload. This result is agreed with previous study obtained by Al-Attar and Shekha [31] and Tawfeeq [32] Which explain that thalassemia major virtual can be diagnose completely within the early days or early months of age because the exhibitions of the disease may perform yet a complete switch from fetal to adult Hb synthesis occurs.

According to the gender there are no significant differences between gender because thalassemia it is a genetic disease that is transmitted from parents to offspring and to both genders equally. These results agreed with the previous study of Al-Attar and Shekha [31].

Saleh and Al-Numan [33] revealed that the prevalence rate of toxoplasmosis in 21/135 sample of thalassemic male patient's genders is (15.6%) while the rate in 21/115 sample of thalassemic percentage of infection among female's patients is (18.3%). However, the prevalence rate of toxoplasmosis in healthy male and female control were 13/30 (43.3%) and 9/20 45%) respectively. The reason of the number increasing of infections in the gender group may be due to the frequency of transfusions.

Conclusion

Our results demonstrate a high seroprevalence of *T.gondii* infection among thalassemic patients**.**

Disclosure

None

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References

1. Al-Aubaidi, I.K.; Saeed, S.A. and Jaaffar, A.I. Blood Lymphocytes Detection in Iraqi Diabetic Type 2 Patients Infected with Chronic Toxoplasmosis by Using Flow Cytometry. Indian Journal of Forensic Medicine and Toxicology, 2020,14(4), 2297–2303.
2. Assim, M. M.; Saheb, E. J. The association of severe toxoplasmosis and some cytokine levels in breast cancer patients. *Iraqi J. Sci.,* ***2018***,59(3A),1189–1194.
3. Saeed, S.A. and Al-Aubaidi IK .(2023). Assessment ofInterleukin-10 Levels in Iraqi Diabetic Type 2 Patients Infected with Toxoplasmosis. Adv. Life Sci. 10S(1): 62-66.
4. Hade, B. F. ; Ghareeb, A.M. ; Kawan,M.H.Direct Amplification of B1 gene of Toxoplasma gondii DNA using Nested Polymerase Chain Reaction Following Microwave Treatment for Whole Blood Samples. *Iraqi J. Vet. Med.,* **2015**,39(1), 23–27.
5. Saeed, S. A. ; Al-Aubaidi, I. K. Seroprevalence of Toxoplasmosis Antibodies among Diabetes Mellitus Patients and Assessment some Biochemical Markers. Ibn AL-Haitham Journal for Pure and Applied Sciences,2018, 2017, 539–551.
6. Almeria, S.; Dubey, J.P. Foodborne transmission of Toxoplasma gondii infection in the last decade an Overview. *Res. Vet. Sci.,* **2021**,135, 371–385.

7. Zeiny, S.M. The correlation between HLA class II and β-thalassemia major in Al-Karama teaching hospital. J.Fac. Med. Baghdad.,2016,58 (4),366-370.
8. Al-Ali,S.A.; Al-Musawi,R.A. The Relevance of rs34598529 SNP of HBB Gene among β-thalassemic Patients Dependent on Blood Transfusions in Thi-Qar Governate. IJB.;2022,21(2), 668-676.
9. Khalaf , M.A.;Al-Saadi,B.Q.;Ewaid,S.H. Evaluation of AHSP Gene Expression and Its Serum Level in Iraqi β-thalassemia Major Patients. I.J.B.,2022,21(2),115-123.
10. He, L.N.; Chen, W.; Yang,Y.; Xie, Y.J.; Xiong, Z.Y.;Chen, D.Y.; Lu, D.; Liu, N.Q.; Yang,Y.H.;Sun, X.F. Elevated Prevalence of Abnormal Glucose Metabolism and Other Endocrine Disorders in Patients with β-Thalassemia Major: A Meta-Analysis. Biomed Res Int. 2019; 2019,1 – 13.
11. Sarkar,S.K.;Shah,M.S.;Begum,M.;Yunus,A.M.;Aziz,M.A.;Kabir,A.L.;Khan,M.R.; Rahman,F.;Rahman,A. Red Cell Alloantibodies in Thalassaemia Patients Who Received Ten or More Units of Transfusion. *Mymensingh Med J*. **2019**,28(2),364-369.
12. Shafique, F.; Ali, S.; Almansouri, T.; Van Eeden, F.; Shafi, N.; Khalid, M.; Khawaja, S.; Andleeb, S.; Hassan, M.U. Thalassemia, a human blood disorder. *Braz. J. Biol*.,**2021**, 3(83), 1-8.
13. SAS. Statistical analysis system, user's guide. Statistical. Version 9. 6th Ed. *Inst. Inc*. Cary. N.C.,**2018**, USA.
14. Shihab,R.N.;Al-Aubaidi, I.K..(2023). Regulatory role of Interleukin 10 in Iraqi thalassemic patients infected with Toxoplasmosis.commprac.J.,20(6):97-102.
15. Abood,M.A; Saheb,E.J. The Variable Levels of IL-6 and Nitric Oxide in Hemodialysis Patients upon Exposure to Toxoplasmosis. I.J.B.,2022,21(2),161-171.
16. Belkacemi, M.;Heddi, B. Toxoplasmosis Immunity Status of Blood Donors in Sidi Bel Abbès, West Algeria. *Cureus*. **2022** ,6;14(9):1-8.
17. Li, Q.; Wang, L.; Sun, Y.; Liu, J.; Ma, F.; Yang, J.; Zhao, D.; Zhang, Y.; Luo, J.; Guo, J.; Deng, R.; Zhang, G. Evaluation of an immunochromatographic strip for detection of avian avulavirus 1 (Newcastle disease virus). *J. Vet. Diagn. Invest*., **2019**,31, 475–480.
18. Yasukawa,T.;Mizutani,F.;Suzuki,M.13-Point of care testing apparatus for immunosensing,1st Ed. Mitsubayashi,K.; Niwa,O.;Ueno,Y. Chemical, Gas, and Biosensors for the Internet of Things and Related Applications,*Elsevier*,**2019**, 193-205.
19. Bakir, A.; Guney, M. (2022). Determination of Low IgG class antibody avidity percentage by IgM levels specific to Toxoplasma gondii. *Clin. Lab.,* 2022,68(8), 944 – 949.
20. Fong, I.W. Blood Transfusion-Associated Infections in the Twenty-First Century: New Challenges. *Current Trends and Concerns in Infectious Diseases*. **2020** ,7,191–215.
21. Abdulla,F.K.;Ahmad,N.A.;Abbas,S.K.h.C-Reactive Protein and Some Hematological, Biochemical Parameters in β-Thalassemia Patients with Cryptosporidiosis. *Annals of R.S.C.B*., **2021**, 25(6), 3831 – 3842.

22. Al-Maamuri, S. D.; Al-Shanawi, F.A.; Melconian, A.K. A. Seroprevalence of Toxoplasma gondii in schizophrenic patients in Iraq using ELISA test. *Iraqi Journal of Science*.,**2014**, 55(3),1243-1248.
23. Hanifehpour, H.; Samsam Shariat, S.K.; Ghafari, M.S.; Kheirandish, F.; Saber, V. and Fallahi, S. Serological and molecular diagnosis of Toxoplasma gondii infections in thalassemia patients. *Iran J. Parasitol.,* **2019**,14(1), 20-28.
24. Gluba-Brzózka, A.; Franczyk, B.; Rysz-Górzyńska, M.; Rokicki, R.; Koziarska-Rościszewska, M.; Rysz, J. Pathomechanisms of Immunological Disturbances in β-Thalassemia. *Int. J. Mol. Sci.,* **2021**, 22(9677),1-13.
25. Karakaş, S.; Ozlem, S.; Tellioğlu, A.M.; Ertabaklar, H.; Ertuğ, S.; Aydın, İ. Beta talasemi majorlü olgularda anti-Toxoplasma gondii IgG ve IgM antikorlarının araştırılması investigation of anti-Toxoplasma gondii IgG and IgM antibodies in beta-thalassemia major patients in Aydın province. *Turkiye Parazitol Derg.,* **2012,**36(3): 133-136.
26. Angastiniotis, M.; Lobitz, S. Thalassemias: An Overview. *Int. J. Neonatal Screen.* **2019** , 20;5(1),1-11.
27. Al-Momen, H. (2017). Iron chelation therapy in sickle cell/beta thalassemia syndrome, a 2 years' extension study. AL-Kindy Col. Med. J., 13(1): 76–81.
28. Ahmed, A. K.; Yenzeel, J. H. Determination of some oxidative stress parameters and antioxidants in sample of Iraqi beta thalassemia major patients. *Iraqi J. Sci.*,**2017**, 58(1A), 1–3.
29. Coates, T.D. Iron overload in transfusion-dependent patients . *Hematology Am. Soc. Hematol. Educ. Program.* , **2019** (1), 337–344.
30. Fadhil, S.; Abdulla, A. A.; Jebor, M. A. Comparison of hematological parameters and serum enzymes in β-thalassmia major patients and healthy controls. *Int. J. Med. Pharm. Sci.,* **2015**,5(6), 29-38.
31. Al-attar, M. S.; Shekha, M. S. The prevalence of thalassemia in Erbil Province. *Uni.Of Salahaddin-Hawler Iraqi Kurd. J.*,**2014**, 2(1), 46–55.
32. Tawfeeq, A. A Prospective study for the outcomes of thalassemia in Kirkuk 2016. *J. Colleg.Scien. of Kirkuk Uni.,***2016**, 17(10), 13–22.
33. Saleh A.Y.;Al-Numan A.Y.S. Investigation of the incidence of toxoplasmosis and cytomegalovirus in patients with thalassemia. *Tikrit J Pure Sci.,* **2019**,23(10), 14-18.

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