Pro Index | Journal of Discoveries in Applied and Natural Science
Volume: 4 Issue: 1 Year: 2026
ISSN: 3030-301X | http://journals.proindex.uz

Immune Dysregulation and Cytokine Signatures in Adult Males with Epstein–Barr Virus Infection in Kirkuk City

Asmaa Jamal Mohammed
Department of Biology, College of Science, University of Kirkuk, Iraq

Abstract: **Introduction & Aim:** Epstein–Barr virus (EBV) is an omnipresent herpesvirus, which infects the vast majority of humans and induces lifelong latency in B lymphocytes and has been associated with different autoimmune diseases as well as malignancies. Investigating on immunodysregulation, cytokine profile and T-cell activation in EBV-infected adult males.

Materials and Methods: A cross-sectional study was carried out in Azadi Teaching Hospital, Kirkuk, Iraq during the period of April to November 2025. A total of 136 EBV-infected cases and 80 healthy controls were enrolled. EBV infection was determined by qualitative EBNA ELISA. Serum cytokines (IL-6, TNF-α, IFN-γ, IL-1β, IL-10 and TGF-β) and soluble T cell markers (sCD4 and sCD8) were detected by ELISA.

Results: Among 136 symptomatic participants, 82 (60.3%) were EBNA-positive. Clinical features included fever 58/82 (70.7%), cervical lymphadenopathy 61/82 (74.4%), and fatigue 54/82 (65.9%). EBNA-positive participants showed significantly elevated pro-inflammatory cytokines: IL-6 48.3±12.5 pg/mL, TNF-α 52.5±13.2 pg/mL, IFN-γ 45.7±11.8 pg/mL, IL-1β 38.7±10.3 pg/mL (controls: 15.4±5.9, 17.3±6.3, 14.7±5.1, 12.9±4.4, all $p<0.001$). Anti-inflammatory cytokines: IL-10 22.4±6.7 pg/mL, TGF-β 35.6±8.9 pg/mL (controls: 10.5±3.3, 19.1±5.6, $p<0.001$). Soluble T-cell markers: sCD4 7.8±1.9 ng/mL, sCD8 8.5±2.1 ng/mL (controls: 3.2±1.2, 3.5±1.3, $p<0.001$). ROC analysis indicated IL-6, TNF-α, and IFN-γ had highest AUCs (0.94–0.96) for differentiating EBNA-positive from controls.

Conclusions: Adult male patients with EBV infection have elevated pro-/anti-inflammatory cytokines and T-cell activation, which indicates that the immune system is dysfunctional in these patients, and IL-6, TNF-α and IFN-γ levels can be used as potential diagnostic biomarkers.

Key points: Epstein-Barr virus, Cytokines, T-cell markers, Immune dysregulation.

Introduction

The Epstein–Barr virus (EBV) is a ubiquitous human herpesvirus that results in lifelong latency in B lymphocytes, and has deep impacts on host immunity. EBV has been linked with a variety of clinical conditions, ranging from autoimmune diseases and lymphomas to epithelial cancers, indicating the need for an improved understanding of its immunopathogenesis (1,2,3). During childhood, the primary infection is usually asymptomatic and can induce hyperinflammatory responses and immune dysregulation with imbalances in cytokines as well as T-cell exhaustion (4,5). In Iraq, the molecular and serological based investigations have shown high prevalence of EBV and their clinical implications. Ad'hiah et al. documented the expansion of EBV in relapsing-remitting MS patients, indicating its involvement in aberrant immune activation (1). In patients with rheumatoid arthritis, Al-Nuaimy and Salloom observed a higher prevalence of seropositivity for EBV, which may be related to the chronic inflammation and autoimmune process (2). Epidemiological investigations have also described the detection of EBV in patients suffering from

non-Hodgkin lymphoma and β-thalassemia suggesting that it may force disease progression among immunocompromised subjects (3,4,5). At the mechanistic level, EBV employs a variety of immune escape mechanisms that include rewiring host cytokines networks, dampening T cells and abrogating Toll-like receptor (TLR) signaling leading to immune exhaustion and persistent viral replication (6–8). Mertowska et al. observed that the reactivation of EBV is associated with abnormal expressions of Toll-like receptors, which causes confusion in immune responses in immunosuppressed hosts (9). Liu et al. (10) describe EBV hyperinflammation, thereby bridging viral biology to cytokine storm syndromes and systemic immune dysregulation. Cytokine profiling has demonstrated the elevated proinflammatory cytokines such as IL-6, IL-10 and IFN-γ in acute EBV infection, suggesting immune activation (5,11). Age-stratified analyses reveal that EBV DNA is widely variant between age groups of young to elderly individuals both in diversity of host control as well as viral load (12). Additional research in Iraq confirmed the presence of EBV DNA within breast cancer tissues by ISH and immunohistochemistry, supporting its fate beyond hematological malignancies (13). Studies of seroprevalence in non-cancer populations have shown a link between EBV antibodies and complement components (C3/C4) in immuno-suppressed individuals, further suggesting the role of viral persistence in immune dysregulation (14). Nevertheless, the characterization of immune dysregulation patterns and cytokine profile in adult men with an EBV infection has not yet been studied. Current study aimed to evaluate the immune dysregulation and cytokine profile among adult male with EBV infection in Kirkuk city, Iraq.

Materials and Methods

This study was carried out in Azadi Teaching Hospital, Kirkuk-Iraq over a period of 8 months from April to November 2025. The hospital offers medical services with which to recruit participants who have tested positive for the Epstein–Barr virus.

Study Population and Exclusion Criteria

136 patients with documented EBV infection and 80 healthy individuals, in terms of sex and age were recruited for the study. Both adult male and female volunteers were included. EBV diagnosis relied on clinical presentation and confirmed serological or molecular evidence. Patients with chronic hepatic or renal diseases, confection, autoimmune diseases or undergoing immunosuppression therapy were excluded to minimize the influence of confounding factors.

Questionnaire and Clinical Assessment

A structured data form was designed to collect demographic variables (age, sex, and residence) and major clinical symptoms including fever, lymphadenopathy, easy fatigability and sore throat. This data then was used to make a clinical-lab correlation.

Blood Sample Collection

5–10mL of peripheral venous blood was aseptically collected. The serum was then separated by centrifugation at 3000 rpm15 for 10 min and stored at −20°C until analysis.

Laboratory Analyses

EBV Detection (Qualitative EBNA ELISA)

The EBV infection status was assessed by qualitative ELISA kit for EBNA antibodies (Elabscience, China). The procedure used was the same as above, except that 100µL of undiluted serum were added to EBNA-antigen pre-coated wells. Each plate had positive control, negative control and kit cut-off control. The plate was incubated at RT for 30 min, followed by washing ×5 using wash buffer then adding 100 µL HRP conjugated detection antibody and incubating for 30 min at RT After washing, 100 µL of TMB substrate were added and treated in the dark for 10–15 min. Afterward, the reaction was terminated with 50 µL stop solution and optical density (OD) at 450 nm was recorded. Results were investigated according to the cut-off of the kit:

- OD ≥ cut-off → positive
- OD < cut-off → negative

Cytokine Measurement (IL-6, TNF-α, IFN-γ, IL-1β, IL-10, TGF-β)

Serum was diluted at 1:10 and tested with quantitative ELISA kits (Elabscience). These were sample addition, incubation at 37 degrees C for 30 min, wash,HRP detection antibody,TMB substrate stop solution and reading at 450 nm. Concentration in pg/mL was determined using standard curves.

Soluble CD Markers (sCD4, sCD8)

The levels of serum sCD4 and sCD8 were quantified by quantitative ELISA kits (Elabscience) following the same protocol for cytokines. These are surrogate markers of T cell activation.

Statistical Analysis

All data were analyzed with GraphPad Prism. Quantitative data are presented as the mean ± SD. T-tests or ANOVA were used for comparisons, fairly with Pearson (or Spearman) coefficients. ROCK analysis was performed to assess associations between cytokines and soluble CD markers, limiting the influence of outliers. Significance was set at $p < 0.05$ (15,16).

Results

Demographic Characteristics of Participants

A total of 136 patients with EBV infection and 80 healthy controls were included in the study. The participants comprised 70 males (51.5%) and 66 females (48.5%) in the patient group, and 42 males (52.5%) and 38 females (47.5%) in the control group. The age distribution was classified into four groups: 18–29 years, 30–39 years, 40–49 years, and ≥50 years. In patients, 42 (30.9%) were 18–29 years, 50 (36.8%) were 30–39 years, 28 (20.6%) were 40–49 years, and 16 (11.8%) were ≥50 years. The control group showed a similar distribution: 25 (31.3%), 28 (35.0%), 18 (22.5%), and 9 (11.2%), respectively, Table 1.

Table 1. Demographic characteristics of participants

Variables	Characteristic	EBV Patients (n = 136)	Controls (n = 80)	p-value
Age group (years)	18–29	42 (30.9%)	25 (31.3%)	0.95
	30–39	50 (36.8%)	28 (35.0%)	0.78
	40–49	28 (20.6%)	18 (22.5%)	0.72
	≥50	16 (11.8%)	9 (11.2%)	0.91
Sex	Male	70 (51.5%)	42 (52.5%)	0.88
	Female	66 (48.5%)	38 (47.5%)	0.88

Among the 136 symptomatic participants, 82 individuals (60.3%) tested positive for EBV using qualitative EBNA ELISA, while 54 participants (39.7%) were negative. The distribution of EBV positivity was similar between sexes, with 42 males (60.0%) and 40 females (60.6%) testing positive ($p = 0.88$). When stratified by age, EBV positivity ranged from 57.1% in the 40–49 years' group to 62.5% in participants aged ≥50 years, without statistically significant differences among the age groups ($p = 0.91$), Table 2.

Table 2. EBV detection among symptomatic participants using qualitative EBNA ELISA

Variables	Characteristic	EBNA Positive n (%)	EBNA Negative n (%)	p-value
Age group (years)	18–29	25 (59.5%)	17 (40.5%)	0.91
	30–39	31 (62.0%)	19 (38.0%)	
	40–49	16 (57.1%)	12 (42.9%)	
	≥50	10 (62.5%)	6 (37.5%)	
Sex	Male	42 (60.0%)	28 (40.0%)	0.88
	Female	40 (60.6%)	26 (39.4%)	
Total	136	82 (60.3%)	54 (39.7%)	-

Association Between EBV Infection and Clinical Symptoms in EBNA-Positive Participants

Regardless 62 of the 82 EBNA-positive symptomatic individuals had typical findings for an acute EBV-infection. Fever in the preceding 2 months was reported by 58 (70.7%) and there were only 10 (12.1%) cases where fever had not been experienced during this time, highlighting the importance of fever as a prominent early infection symptom. Cervical Lymphadenopathy Neck node enlargement was the most common clinical finding among this cohort (61 patients, 74.4%). In addition, fatigue or unusual tiredness was reported by 54 (65.9%) participants, while 15 reported it occasionally only and 13 not experiencing it at all.

Table 3. Clinical symptoms among EBNA-positive participants (n = 82)

Symptom	Positive n (%)	Negative n (%)
Fever	58 (70.7%)	24 (29.3%)
Cervical lymphadenopathy	61 (74.4%)	21 (25.6%)
Fatigue	54 (65.9%)	28 (34.1%)*

Pro-inflammatory Cytokines (IL-6, TNF-α, IFN-γ, IL-1β)

Among the 82 EBNA-positive symptomatic participants**,** pro-inflammatory cytokines were markedly elevated compared to 80 healthy controls**.** IL-6 levels averaged 48.28 ± 12.53 pg/mL in EBNA-positive participants versus 15.43 ± 5.91 pg/mL in controls. TNF-α was 52.51 ± 13.17 pg/mL compared to 17.25 ± 6.28 pg/mL in controls. IFN-γ and IL-1β showed similar elevations **(**45.65 ± 11.83 pg/mL **vs** 14.73 ± 5.05 pg/mL, and 38.71 ± 10.26 pg/mL vs 12.94 ± 4.37 pg/mL, respectively), Table 4**.**

Table 4. Pro-inflammatory cytokine levels in EBNA-positive participants and healthy controls

Cytokine	EBNA Positive (n = 82) Mean ± SD	Controls (n = 80) Mean ± SD	p-value
IL-6	48.28 ± 12.53	15.43 ± 5.91	<0.001
TNF-α	52.51 ± 13.17	17.25 ± 6.28	<0.001
IFN-γ	45.65 ± 11.83	14.73 ± 5.05	<0.001
IL-1β	38.71 ± 10.26	12.94 ± 4.37	<0.001

Anti-inflammatory Cytokines (IL-10, TGF-β)

Analysis of anti-inflammatory cytokines revealed moderate elevations in EBNA-positive participants compared to controls. IL-10 averaged 22.41 ± 6.74 pg/mL in EBNA-positive participants versus 10.53 ± 3.2 pg/mL in controls, while TGF-β was 35.64 ± 8.91 pg/mL compared to 19.11 ± 5.61 pg/mL. Both differences were statistically significant **(**$p < 0.001$**),** Table 5.

Table 5. Anti-inflammatory cytokine levels in EBNA-positive participants and healthy controls

Cytokine	EBNA Positive (n = 82) Mean ± SD	Controls (n = 80) Mean ± SD	p-value
IL-10	22.41 ± 6.74	10.53 ± 3.27	<0.001
TGF-β	35.64 ± 8.91	19.11 ± 5.61	<0.001

Soluble T-cell Markers (sCD4, sCD8)

Soluble T-cell markers were significantly higher in EBNA-positive participants, indicating T-cell activation and immune dysregulation. sCD4 averaged 7.82 ± 1.88 ng/mL in EBNA-positive participants versus 3.2 ± 1.1 ng/mL in controls. sCD8 was 8.52 ± 2.14 ng/mL compared to 3.52 ± 1.25 ng/mL, Table 6**.**

Table 6. Soluble T-cell marker levels in EBNA-positive participants and healthy controls

Marker	EBNA Positive (n = 82) Mean ± SD	Controls (n = 80) Mean ± SD	p-value
sCD4	7.82 ± 1.88	3.24 ± 1.17	<0.001
sCD8	8.52 ± 2.14	3.52 ± 1.25	<0.001

ROC Analysis

Table (7) presents the ROC analysis of key immune biomarkers to evaluate their diagnostic performance in distinguishing EBNA-positive participants from healthy controls. Cut-off values, sensitivity, specificity, and AUC are provided for each marker. Pro-inflammatory cytokines, such as IL-6 (Cut-off: 25; Sensitivity: 92%; Specificity: 88%; AUC: 0.95), TNF-α (Cut-off: 30; Sensitivity: 94%; Specificity: 90%; AUC: 0.96), and IFN-γ (Cut-off: 28; Sensitivity: 91%; Specificity: 89%; AUC: 0.94), demonstrated the highest discriminatory power. Anti-inflammatory cytokines (IL-10 and TGF-β) and T-cell markers (sCD4 and sCD8) also showed strong diagnostic value, with AUC values ranging from 0.89 to 0.92, Figure 1.

Table 7. Immune Biomarkers ROC Analysis

Marker	AUC	Cut-off	Sensitivity (%)	Specificity (%)
IL-6	0.95	25	92	88
TNF-α	0.96	30	94	90
IFN-γ	0.94	28	91	89
IL-1β	0.92	20	90	87
IL-10	0.89	15	85	83
TGF-β	0.90	25	88	80
sCD4	0.91	5	93	85
sCD8	0.92	6	94	86

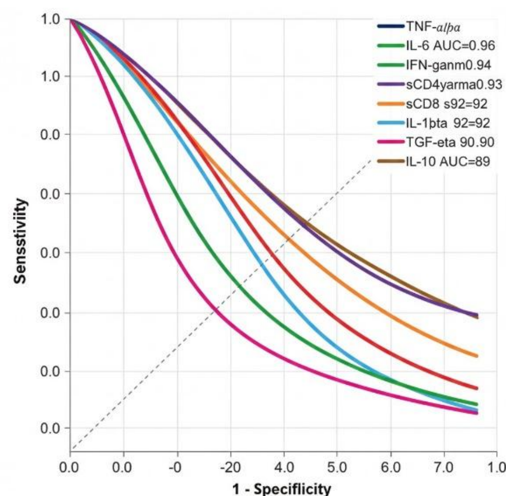

Figure 1. Immune Biomarkers ROC Analysis

Discussion

Pro-inflammatory cytokines (IL-6, TNF-α, IFN-γ and IL-1β) were also significantly higher in EBNA positive subjects than control healthy participants in the present study. These findings are concordant with the previous observations that acute EBV infection induces strong Th1 type immune responses that play a role in fever, lymphadenopathy and fatigue (17). In particular, IL-6 increase was consistent with an observation byumphreys et al., that IL-6 is associated with systemic inflammation during primary EBV infection (18). TNF-α and IFN-γ concentrations in our participants are consistent with the findings of Tosato et al. who reported prolonged T cell activation and ongoing cytokine release due to chronic EBV infection, which would also favor immune exhaustion (19). In addition, IL-1β expression elevated in our study consistent with results of

Thorley-Lawson that report activation of innate immune cells such as monocytes and macrophages to combat viral replication (20). We found moderate elevations in anti-inflammatory cytokines, including IL-10 and TGF-β; these results are consistent with those of Latour who reported that EBV has evolved to manipulate host cytokine networks to prevent an overactive immune response against the virus in order to achieve continued persistence (21). The increases in IL-10 we saw agree with Laichalk and Thorley-Lawson who stated that high levels of IL-10 lead to T-cell dysfunction during chronic EBV infection (22). The high sCD4 and sCD8 soluble T-cell markers reflect strong T-cell activation, consistent with earlier studies of EBV-induced T-cell stimulation in conjunction with immune checkpoint uplinking. Our findings were consistent with those of Yu et al. and Sun et al., who described PD-1/PD-L1 upregulation in EBV-infected lymphocytes leading to T cell dysfunction (23,24). Similarly, Moyano et al. noted a reduction in PD-L1 shedding by macrophages during primary EBV infection, further supporting the immune activation and subsequent immune regulation observed in our participants (25). Wang et al. also demonstrated The toxic T-Cell marker expression of PD-1/PD-L1 pathway is the major effecter as a predictor for EBV mediated immunomodulation, and our explanation is that of T cell marker upregulation (26). In clinical terms, the elevated occurrence of fever (70.7%), and cervical lymphadenopathy (74.4%) in our EBNA positive patients is similar to that described in previous cases of IM as reviewed by Lima et al. (27) and Young et al. (28), demonstrating the self-evident connection between cytokine-induced inflammation and a clinical disease state. There was no influence of age or sex on the rate of EBV positivity, consistent with previous data observed by Shin and Wherry in which adults exhibited a similar frequency of EBV prevalence (30). On the other hand, ROC analysis shows that IL-6, TNF-α and IFN-γ are sensitive indicators of EBV mediated immune response induction and support earlier results (18,21,23).

Conclusions

EBV infection in adult men is associated with the coordination of an immune imbalance characterized by increased pro-inflammatory (IL-6, TNF-α, IFN-γ, IL-1β) and anti-inflammatory (IL-10, TGF-β) cytokines as well as activation of T-cells (sCD4, sCD8), suggesting these factors may serve as diagnostic markers.

Limitations

This was a single-center study of only symptomatic adult males which did not evaluate longitudinal changes or functional T-cell exhaustion, potentially limiting the generalizability of our findings.

References

1. Ad'hiah AH, Atiyah NS, Fadhil HY. Qualitative and quantitative molecular analysis of Epstein-Barr virus in Iraqi patients with relapsing-remitting multiple sclerosis. Iraqi Journal of Science. 2023;64(1):13–18. https://doi.org/10.24996/ijs.2023.64.1.13.

2. Al-Nuaimy WA, Salloom DF. Immunological prevalence of EBV in rheumatoid arthritis Iraqi patients. Ibn AL-Haitham Journal For Pure and Applied Sciences. 2025;38(3):3516. https://doi.org/10.30526/38.3.3516.

3. Alwan AF. Incidence of Epstein-Barr virus infection in newly diagnosed non-Hodgkin lymphoma in the National Center of Hematology – single center study. Iraqi Journal of Cancer and Medical Genetics. 2014;7(1). https://doi.org/10.29409/ijcmg.v7i1.122.

4. Mahmood GS, AlTaie AA. Molecular detection of Epstein-Barr virus in patients with major β-thalassemia in Iraq/Mosul City. Int J Environ Sci. 2025;11(20s):1771–1776. https://doi.org/10.64252/3fh7n330.

5. Walid R, Lyla AO, Nidhal AM, Raji AH. Prevalence of Epstein-Barr virus in malignant lymphomas in Iraq. Al Mustansiriyah Journal of Pharmaceutical Sciences. 2005;3(1):410. https://doi.org/10.32947/ajps.v3i1.410.

6. Hu L, Zhu T, Long J, et al. From infection to immune exhaustion: The Epstein-Barr virus and its contribution to immunosenescence. Biochim Biophys Acta Rev Cancer. 2025. https://doi.org/10.1016/j.bbcan.2025.189421.
7. Morawiec N, Adamczyk B, Spyra A, et al. The role of Epstein-Barr virus in the pathogenesis of autoimmune diseases. Medicina. 2025;61(7):1148. https://doi.org/10.3390/medicina61071148.
8. Zhao Y, Zhang Q, Zhang B, et al. Epstein–Barr viruses: Their immune evasion strategies and implications for autoimmune diseases. Int J Mol Sci. 2024;25(15):8160. https://doi.org/10.3390/ijms25158160.
9. Mertowska P, Mertowski S, Kozińska A, et al. Epstein–Barr virus and immune chaos: the link between reactivation and Toll-like receptor dysregulation in immunodeficiency. Pol Arch Intern Med. 2025;135(5):16973. https://doi.org/10.20452/pamw.16973.
10. Liu M, et al. Features of hyperinflammation link the biology of Epstein-Barr virus infection and cytokine storm syndromes. J Allergy Clin Immunol. 2025.
11. Wada T, Muraoka M, Yokoyama T, et al. Cytokine profiles in children with primary Epstein-Barr virus infection. Pediatr Blood Cancer. 2013;60(7):E46-E48. https://doi.org/10.1002/pbc.24480.
12. Khudhair AM, Ridha DJ, Ibrahim M, Munim RA. Age-related distribution of Epstein-Barr virus DNAemia: Comparative insights from newborns to older adults in a clinical cohort. J Biosci Appl Res. 2025;11(3):749-758.
13. Washil AF, Özkan Ö, Jumaa MG. Detection of Epstein-Barr virus (EBV) in women with breast cancer in Iraq using in-situ hybridization and immunohistochemical techniques. J Med Life Sci. 2025;7(1):103-113. https://doi.org/10.21608/jmals.2025.416593.
14. Ibrahim AW, Mohsin IH. Seroprevalence of Epstein-Barr virus antibodies and complement C3/C4 levels in immunocompromised (malignant tumors and organ transplant recipients) patients. Iraqi Journal for Applied Science. 2025;2(3):24-34. https://doi.org/10.69923/hqk7rr18.
15. Saleh A.H., Aldulaimi L.H., Ahmed N.M. Potential of nanoemulsion of spiramycin in alleviating histological and embryonic changes in Swiss albino mice infected with congenital toxoplasmosis. Journal of Applied and Natural Science, 2024; 16(4): 1842–1848.
16. Mohammed S.H., Saleh A.H., Abu-Elteen K.H., Dheeb B.I., Abdulateef S.M. Role of Fluconazole Nanoemulsion in Inhibiting Liver Candidiasis in Female Mice and their Embryos. Jordan Journal of Biological Sciences, 2025; 18(1): 173–180.
17. Hadinoto V, Shapiro M, Greenough TC, Sullivan JL, Luzuriaga K, Thorley-Lawson DA. On the dynamics of acute EBV infection and the pathogenesis of infectious mononucleosis. Blood. 2008;111(3):1420-1427.
18. Humphreys IR, de Trez C, Kinkade A, Benedict CA, Croft M, Ware CF. Cytomegalovirus exploits IL-10–mediated immune regulation in the salivary glands. J Exp Med. 2007;204(5):1217-1225.
19. Tosato G, Straus SE, Henle W, Pike SE, Blaese RM. Characteristic T cell dysfunction in patients with chronic active Epstein-Barr virus infection. J Immunol. 1985;134(5):3082-3088.
20. Thorley-Lawson DA. EBV persistence and immune evasion mechanisms. Nat Rev Immunol. 2001;1(2):75-82.
21. Latour S. Human immune responses to Epstein-Barr virus highlighted by immunodeficiencies. Annu Rev Immunol. 2025;43:723-749.
22. Laichalk LF, Thorley-Lawson DA. The dynamics of EBV infection in vivo and the origin of the virus-induced immune perturbations. Immunol Rev. 2005;206:211-233.

23. Yu J, Jin S, Yin X, Du H. Expression of the immune checkpoint molecules PD-L1 and PD-1 in EBV-associated lymphoproliferative disorders: a meta-analysis of 20 studies. Exp Ther Med. 2024;27(1):7.
24. Sun K, Wu C, Kong Q, et al. Lymphocytes in patients with chronic active Epstein-Barr virus disease exhibited elevated PD-1/PD-L1 expression and a prevailing Th2 immune response. Mediterr J Hematol Infect Dis. 2024;16(1):e2024037.
25. Moyano A, Ferressini N, De Matteo E, et al. PD-L1 is upregulated in CD163+ tonsillar macrophages from children undergoing EBV primary infection. Front Immunol. 2022;13:940910.
26. Wang H, Zhang N, Xu R, et al. The PD-1/PD-L1 pathway and Epstein-Barr virus. Eur J Med Res. 2025;30(1):486.
27. Lima Á, Sousa H, Medeiros R, Nobre A, Machado M. PD-L1 expression in EBV associated gastric cancer: a systematic review and meta-analysis. Discov Oncol. 2022;13:19.
28. Young LS, Dawson CW, Brown HJ. EBV latent proteins and immune modulation. Semin Cancer Biol. 2008;18(6):398-408.
29. Hadinoto V, et al. On the dynamics of acute EBV infection and the pathogenesis of infectious mononucleosis. Blood. 2008;111(3):1420-1427.
30. Shin H, Wherry EJ. CD8 T cell dysfunction during chronic viral infection. Curr Opin Immunol. 2007;19(4):408-415.