North Clin Istanb 2025;12(1):29–35
doi: 10.14744/nci.2023.88886

Original Article MEDICAL MICROBIOLOGY

Analysis of QuantiFERON®-TB Gold Plus test results among patients with chronic inflammatory diseases and HIV patients

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ABSTRACT

OBJECTIVE: Screening for latent tuberculosis (LTB) is necessary, especially for people living with human immunodeficiency virus (HIV) and people receiving anti-TNF therapy. Although there is no microbiological test accepted as the gold standard, interferon-gamma release assays (IGRAs) are suggested to be used by World Health Organization. We aimed to analyze QuantiFERON®-TB Gold Plus test results in different patient groups with high reactivation risk.

METHODS: Patients admitted to Marmara University Pendik Training and Research Hospital Microbiology Laboratory between August 2016 - March 2020 have been analyzed retrospectively. Patient demographic data was obtained from the records of the laboratory information management system. Blood samples have been studied as recommended by the manufacturer (QuantiFERON®-TB Gold Plus, QIAGEN, Germany).

RESULTS: We evaluated samples from 1506 patients, of whom with a chronic inflammatory disease (CID) in 1223 patients and HIV positivity among 283 patients. Mean age was 38.29±12.66 for HIV patients and 41.57±14.45 for chronic inflammatory disease patients. QFT test was positive in 319 (21.2%) of 1506 patients in total and in 43 (15.2%) of HIV patients and in 276 (22.6%) of CID patients. Indeterminate results were obtained in 1.7% (n=26) of the samples. Among patients with CID highest rate of QFT test positivity was detected among patients with psoriasis (27.8%), followed by patients with rheumatoid arthritis (21.8%) and ankylosing spondylitis (19.8%). Active tuberculosis was not developed in any of QFT-GIT-positive CID patients followed up in our hospital for the 4 years period.

CONCLUSION: QuantiFERON®-TB Gold Plus test requires a short-term and one-time contact with the patient and it seems to be a suitable option for screening of patients who have a high risk of tuberculosis.

Keywords: Anti-TNF treatment; IGRA; latent tuberculosis; mycobacterium tuberculosis; QuantiFERON®-TB Gold Plus.

Cite this article as: *Sayin E, Alci G, Ozanat A, Duman N, Karahasan A. Analysis of QuantiFERON®-TB Gold Plus test results among patients with chronic inflammatory diseases and HIV patients. North Clin Istanb 2025;12(1):29–35.*

Tuberculosis is one of the oldest infectious diseases of humans, and it is estimated that approximately one-quarter of the world population is infected with Mycobacterium tuberculosis. The active tuberculosis disease does not necessarily develop in every infected person, but the bacilli may remain latent in the granuloma. According to the World Health Organization data, there are more than 2 billion people with latent tuberculosis infection (LTBI) and 10 million active tuberculosis patients worldwide. It is expected that 10% of people with LTBI will develop active tuberculosis at some point in their lives. The reactivation of latent infections is highly correlated with the immune status of individuals. The risk of reactivation increases in the

Received: July 18, 2023 *Revised:* November 14, 2023 *Accepted:* December 09, 2023 *Online:* January 06, 2025

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presence of human immunodeficiency virus (HIV) infection where the cellular immune response is weakened, in clinical situations where biological agents such as TNF alpha inhibitors and IL-1 antagonists are used, and in people with underlying lung diseases (silicosis, etc.). Identification and treatment of LTBI in these high-risk patient groups is very important in terms of tuberculosis elimination [1, 2].

Although there is no microbiological test accepted as the gold standard for the diagnosis of LTBI, it has been reported that the Tuberculin Skin Test (TST) or Interferon-gamma release assay (IGRA) can be used for screening according to the Updated and Consolidated Guidelines for the Programmatic Management of LTBI published by WHO (2018) [2]. Similarly, the Diagnosis and Treatment Guideline of the Ministry of Health of Turkiye states that even though both TST and IGRA can be used in diagnoses of LTBI, TST is recommended as the preferred test except for some specific groups in Turkiye [3]. QuantiFERON®-Gold (QFT-G) and QuantiFERON®-TB Gold In-Tube (QFT-GIT) (Qiagen, Cellestis Europe GmbH, QIAGEN, Hilden, Germany) and Immunotec T-SPOT® TB (T-Spot) (Oxford Immunotec, Oxford, UK) tests are the main tests that can be studied from whole blood, based on CD4+ cell response, and recommended by WHO so far in LTBI screening [4]. Those tests are ELISA tests and can be applied in routine laboratories. QuantiFERON®-TB Gold Plus test was started to be used in 2016, and unlike old versions, it is the last generation QFT test that detects CD8+ T cell responses as well as CD4+ [5].

Identifying and treating individuals with LTBI among people who had tuberculosis contact and high-risk groups is very important for tuberculosis elimination goals. "WHO End TB strategy" aims to reduce the incidence of tuberculosis by 80% and deaths due to tuberculosis by 90% compared with the 2015 baseline worldwide by 2030 [1]. However, the COVID-19 pandemic, directing financial and human resources going on for more than two years and has led to interruptions in the diagnosis and treatment of tuberculosis in Turkiye and worldwide. Practices such as lockdowns and quarantine procedures to reduce transmission of COVID cases unfortunately have led to increases in tuberculosis cases and mortality rates due to inability to diagnose and treat TB cases [6, 7]. According to data published by WHO, approximately 623 million confirmed cases and more than 6.6 million deaths have been reported worldwide as of 9 December 2022 due to COVID-19 [8].

Highlight key points

- Identifying and treating individuals with LTBI among people who had tuberculosis contact and high-risk groups is very important for tuberculosis elimination goals.
- The QFT-GIT results of HIV patients and patients having chronic inflammatory diseases planning to receive anti-TNF therapy were analyzed since these groups are suggested to be the main targets for screening for LTBI by WHO.
- QFT test was positive in 319 (21.2%) of 1506 patients in total and in 43 (15.2%) of HIV patients and in 276 (22.6%) chronic inflammatory disease patients. Indeterminate results were obtained in 1.7% (n=26) of the samples
- QFT-GIT test requires a short-term and one-time contact with the patient and it seems to be a suitable option, especially for patients who have a high risk of tuberculosis.

However, it is estimated that the pandemic will cause 6.3 million additional tuberculosis cases and 1.4 million additional tuberculosis-related deaths by the end of 2025 [1]. These data remind us that tuberculosis continues to pose a severe threat while healthcare circles mainly focus their attention on the COVID-19 pandemic.

The lifetime risk of reactivation TB for a person with documented LTBI is estimated to be 5–10%, with the majority developing TB disease within the first five years after initial infection and lifetime risk, is ~50% in HIV coinfected individuals [2–4]. The clinical therapy for patients presenting with chronic inflammatory diseases (CIDs), such as psoriasis, rheumatoid arthritis, often consists of administering biologic drugs, such as tumor necrosis factor (TNF)-alpha antagonists. These drugs may cause reactivation of LTBI, as the drugs act as suppressors of the immune response. In this study, we retrospectively analyzed QFT test results among HIV-positive patients and patients with CID followed in our hospital for 4 years period.

MATERIALS AND METHODS

Cases, Demographic and Clinical Characteristics

QFT-Plus test results of patients admitted to Marmara University Pendik Training and Research Hospital Microbiology Laboratory between August 2016-March 2020 have been analyzed retrospectively. Patient demographic data such as age, gender, and clinical information have been obtained from the records of the laboratory information management system. The Marmara University Faculty of Medicine Clinical Research Ethics Committee approved the study protocol (date: 02.12.2022, protocol code: 09.2022.1569). The study was performed according to Helsinki Declaration.

Table 1. Positivity rates by age and gender in patient groups

	HIV	CID
All patients (n=1506)	283	1223
Female (%)	11.2	49.7
<18	2.8	4.4
≥18	97.2	95.6
Age (Mean+SD)	38.29±12.66	41.57±14.45

HIV: Human immunodeficiency virus; CID: Chronic inflammatory disease; SD: Standard deviation.

QFT-Plus Test Study and Result Evaluation Method

Following the recommendations of the manufacturer (QuantiFERON®-TB Gold Plus, QIAGEN, Germany), blood samples were collected into four tubes; Nil negative control (grey), TB1 antigen (green), TB2 antigen (yellow) and Mitogen positive control (purple) were taken in 1 ml tube and incubated at 37 °C for 16–24 hours. After incubation, the tubes were centrifugated at 2000 to 3000 RCF (g) for 15 minutes and plasma was separated. If the plasma cannot be used immediately, it was stored at +4 °C. A microplate reader with 450 nanometer (nm) and 620–650 nm reference filter was used to determine the IFN gamma concentration. Results with an IFN gamma level ≥0.35 IU/mL were considered positive and IFN gamma level <0.35 IU/mL were considered negative.

Statistical analysis: Descriptive statistics were prepared to include frequency (n), mean, median, standard deviation (STD), minimum and maximum values. Excel 2016 (Redmond, WA, USA) and SPSS (Statistical Package for Social Sciences) version 20.0 (SPSS Inc., Chicago, IL, USA) were used for statistical analysis.

RESULTS

We evaluated 1506 patients during the study period. A chronic inflammatory disease was present among 1223 patients and HIV positivity among 283 patients as seen in Table 1. Only 4.1% of the patients were younger than 18 years of age and 42% were female. Mean age was 38.2 for HIV-positive patients and 41.2 for CID patients.

QFT test was positive in 319 (21.2%) of 1506 patients and positivity was detected in 43 (15.2%) of HIV patients and in 276 (22.6%) of CID patients. Indeterminate results were obtained in 26 (1.7%) of the samples. Age and gender distribution among groups are given in Table 2.

Overall QFT test positivity among CID patients was 22.6%, with the highest rate among patients with psoriasis (27.8%), followed by patients with rheumatoid arthritis (21.8%) and ankylosing spondylitis (19.8%) (Table 3). Indeterminate results were most commonly detected among Crohn's disease (6.7%).

DISCUSSION

In the global tuberculosis 2019 report, Turkiye's 2018 estimated case rate was 16 per 100,000 [9]. WHO recommends using TST or IGRA for LTBI screening in upper- and middle-income countries with a tuberculosis incidence of less than 100 per 100,000. WHO also reports that screening for LTBI is necessary, especially for people living with HIV, adults and children with pulmonary tuberculosis contact, people receiving anti-TNF therapy, dialysis and organ transplant patients, and patients with silicosis [2].

Application of TST requires experienced personnel and interpretation requires a second hospital visit which complicates its utilization. Specificity of TST is relatively low and it may cause false-negative or false-positive results for reasons such as Bacille Calmette Guerin (BCG) vaccination, non-tuberculous mycobacteria (NTM) infection, in immunosuppressed patients. On the other hand, specificity of IGRAs is higher since ESAT-6 and CFP-10 antigens which are present in the M. tuberculosis complex but not in BCG and common NTM are used [10, 11]. The fact that IGRAs can be studied from blood samples and results are available after 24 hours provides a significant advantage, but the test cost is higher than TST.

Following the introduction of IGRA tests in Turkiye, clinical studies have been applied to determine the reliability of IGRA tests for diagnosing LTBI. Dilektasli et al. [12] presented one of the first studies in Turkiye with 91 participants that included culture-confirmed tuberculosis patients, healthy contacts known to have been exposed to M. tuberculosis, and healthy BCG-vaccinated volunteers. The study reported that the negative and positive predictive values for IGRA tests were significantly higher compared to the TST. Metin Timur et al. [13] compared QuantiFERON®-TB gold in-tube test (QFT-GIT) and TST for diagnosis of latent tubercu-

Table 2. QFT positivity according to the age and gender among patients groups

Results	Negative	Positive	Indeterminate	Total	
Age group/cender	%	%	%	n	%
HIV	82.7	15.2	2.1	283	100.0
<18	2.1	–	0.7	8	2.8
Age (Mean±SD)	13.5±3.83	–	9±11.31	12.375±5.76	
Female	1.1	–	–	3	1.1
Male	1.1	–	0.7	5	1.8
≥18	80.6	15.2	1.4	275	97.2
Age (Mean±SD)	39.13±12.08	39.33±11.72	31.5±10.47	39.05±12.0	
Female	7.4	2.8	–	29	10.2
Male	73.1	12.4	1.4	246	86.9
Chronic inflammatory diseases	75.8	22.6	1.6	1223	100.0
<18	3.8	0.2	0.3	54	4.4
Age (Mean±SD)	14.28±2.84	17±–*	15.75±2.63	14.54±2.81	
Female	2.1	0.1	0.1	28	2.3
Male	1.7	0.2	0.2	26	2.1
≥18	72.0	22.3	1.3	1169	95.6
Age (Mean±SD)	40.95±13.20	48.63±12.98	46.57±11.18	42.82±13.51	
Female	38.0	8.9	0.4	579	47.3
Male	33.9	13.4	0.9	590	48.2
Total	77.1	21.2	1.7	1506	100.0

*: SD can not be calculated, since all patients are 17 years old. QFT: QuantiFERON®; HIV: Human immunodeficiency virus; SD: Standard deviation.

losis infection in the children with BCG vaccine. They suggested that positive TST results should be confirmed with tests based on interferon-gamma (IFN-γ) because it can reduce false positive diagnosis and treatment of latent tuberculosis infection, thus adverse reactions of drugs, in countries where BCG vaccination is routinely recommended especially for low-risk children. Camlar et al. [14] stated that TST might be insufficient for diagnosing LTBI in juvenile rheumatoid arthritis patients, producing false-negative results and that the combination of the QFT-GIT method with TST should be used before anti-tumor necrosis factor treatment. Sargin et al. [10] analyzed 109 patients (45 male, 64 female) with the diagnosis of rheumatoid arthritis and ankylosing spondylitis and they compared TST and IGRA tests for detecting latent tuberculosis infection in patients before receiving TNF-α blocking agents. They revealed that IGRA tests are not affected prior to vaccination and useful for detecting latent tuberculosis infection in patients treated with corticosteroids due to lack of correlation between test negativity and corticosteroid therapy and IGRAs are useful tests for diagnosis of latent tuberculosis infection as an alternative to TST due to their specificity and sensitivity. Erol et al. [15] evaluated BCG-vaccinated immunosuppressed patients by comparing TST induration with the QFT-GIT results by taking the cut-off values of 5–10–15 mm. However, they found no statistically significant difference between the groups in terms of test specificity.

We analyzed QFT-GIT results of HIV patients and patients having CID planning to receive anti-TNF therapy since these groups are suggested to be the main targets for screening for LTBI by WHO [2]. HIV infection increases the risk of progressing to active tuberculosis and detection of LTBI is needed to eventually propose preventive therapy and reduce TB reservoir. The positivity rate was 15.2% in our HIV-positive patients (n=234). In a study that compared QFT-Plus sensitivity among different patient groups, QFT was positive in 15% of HIV patients (n=167) and QFT-Plus sensitivity was found similar regardless of HIV status and CD4 count did not influence the distribution of IFN-γ values

Table 3. QFT positivity according to the underlying diseases

Diagnosis type	Negative n=1161, %	Positive n=319, %	Indeterminate n=26, %	Total n=1506, %
HIV	82.7	15.2	2.1	100
Chronic inflammatory diseases	75.8	22.6	1.6	100
Psoriasis	70.9	27.8	1.3	100
Rheumatoid arthritis	77.1	21.8	1.2	100
Ankylosing spondylitis	77.8	19.8	2.4	100
Multiple sclerosis	84.3	15.7	–	100
Crohn's disease	73.1	20.2	6.7	100
Ulcerative colitis	77.3	21.3	1.3	100
Familial Mediterranean fever	83.3	16.7	–	100
Pemphigus vulgaris	77.5	22.5	–	100
Bechet's disease	84.2	15.8	–	100
Total	77.1	21.2	1.7	100

QFT: QuantiFERON®; HIV: Human immunodeficiency virus.

in HIV-TB and HIV-LTBI [16]. Binay et al. [17] compared TST and T-SPOT.TB tests for screening of LTBI in HIV-infected (n=100) individuals. They presented 22% QFT positivity rate and suggested that IGRA test could be preferred in patients with low CD4+ T lymphocyte count. We have not compared our results with TST or analyzed the sensitivity of the test related with the number of CD4 cells in our HIV-infected patients but we may conclude that the positivity rate is similar to the previous studies.

Our national guideline emphasizes that IGRA should be preferred first for those undergoing anti-TNF therapy [3]. Positivity rate of QFT-GIT was 22.6% in our CID group, in which the diagnosis and treatment of LTBI gained importance due to the use of TNF alpha antagonists for treatment. The highest rates in terms of both the number of tests studied and the positivity rate were seen in patients with psoriasis. Karatas Togral et al. [18] reported that TST results were not affected by psoriasis severity and agreement between TST and QFT-GIT results was moderate. A positive rate of 22.5% was found in the pemphigus vulgaris patient group and 21.8% in the rheumatoid arthritis group. Since the risk of active tuberculosis may continue after anti-TNF treatment is stopped, it is recommended to follow up with the patients for at least 6 more months. Hatemi et al. [19] found a positivity rate of 34% in a study in which they evaluated the QFT gold results of patients with a diagnosis of rheumatoid arthritis and reported that the use of anti-TNF did not affect the test results, so the test could also be used in the follow-up of patients during the treatment process. Positivity rate was 20.2% in patients with Crohn's disease and 21.3% in patients with ulcerative colitis. In a retrospective study involving 76 patients diagnosed with inflammatory bowel disease (IBD) receiving anti-TNF therapy, 44.7% of the patients were QFT-GIT-positive and 39.5% were TST-positive [20]. The conversion of LTBI to active tuberculosis occurs mostly within five years following the first infection [21]. To our pleasure, active tuberculosis was not developed in our QFT-GIT-positive CID patients followed up in our hospital for the 4 years period.

Out of the 1506 tests studied, 26 (1.7%) indeterminate results were obtained. Previous studies reported that young age, high WBC count, low albumin level, and steroid treatment could cause indeterminate QFT-GIT results [22]. In addition, it has been reported that limiting the time between blood collection and incubation of the tubes at 37 °C to a maximum of 1 hour reduces the rates of indeterminate results [23]. Unfortunately, we could not explain the reasons for indeterminate results due to retrospectivity of the study.

During COVID-19 pandemic, the technical infrastructure and human resources in our center, like many laboratories in Turkiye and worldwide, had to be devoted to the COVID-19 diagnostic tests, hence causing

limitations in the diagnosis of LTBI. Indeed, the long-term consequences of isolation, quarantine, and similar precautionary practices are still unknown. The data we present with this study covers the month of March 2020, when the first case in our country was announced, and the previous 4-year period. In a study evaluating the data of the pandemic period, it was determined that the rate of LTBI in patients diagnosed with COVID-19 was significantly lower than in the control group, and it was stated that this situation might be the result of suppression of IFN-γ response in the presence of SARS-CoV-2 infection. In the same study, although not statistically significant, the need for oxygen therapy and mortality rates were found to be higher, especially in the QFT-Plus positive group [24]. In a meta-analysis with 2383 patients by Gao et al. [25], it was stated that LTBE infection increased the risk of severe COVID-19 disease approximately twice, but this was not statistically significant, and there was no difference in the probability of contracting COVID-19 infection between people with and without LTBI.

Conclusion

In conclusion, providing diagnosis and treatment of LTBI may prevent active tuberculosis development in infected individuals and transmission to other people. Our QFT-GIT results, which are also used in our hospital for this purpose, were found to be compatible with the data of the world and Turkiye. At the same time, since QFT-GIT tests require a short-term and one-time contact with the patient, it seems to be a suitable option, especially for the high-risk patients for tuberculosis.

Ethics Committee Approval: The Marmara University Clinical Research Ethics Committee granted approval for this study (date: 02.12.2022, number: 09.2022.1569).

Authorship Contributions: Concept – AK; Design – AK, GA, ES; Supervision – AK; Fundings – AK; Materials – AK, ES, AO, ND; Data collection and/or processing – ES, AO, ND, GA; Analysis and/or interpretation – GA, AK; Literature review – AK; Writing – ES, AK, GA; Critical review – AK.

Conflict of Interest: No conflict of interest was declared by the authors.

Use of AI for Writing Assistance: The authors declared that they did not use artificial intelligence (AI) assisted technologies (such as Large Language Models [LLMs], chatbots or image generators, ChatGPT) in the production of the submitted work.

Financial Disclosure: The authors declared that this study has received no financial support.

Peer-review: Externally peer-reviewed.

REFERENCES

1. World Health Organization. Global tuberculosis report 2021. Available at: https://www.who.int/publications/i/item/9789240037021. Accessed Sept 13, 2024.
2. World Health Organization. Latent TB infection: updated and consolidated guidelines for programmatic management. Available at: https://iris.who.int/handle/10665/260233. Accessed Sept 13, 2024.
3. Türkiye Cumhuriyeti Sağlık Bakanlığı. Tüberküloz tanı ve tedavi rehberi - 2019. Available at: https://hsgm.saglik.gov.tr/depo/birimler/tuberkuloz-db/Dokumanlar/Rehberler/Tuberkuloz_Tani_ve_Tedavi_Rehberi.pdf. Accessed Sept 13, 2024.
4. World Health Organization. Use of alternative interferon-gamma release assays for the diagnosis of TB infection: WHO policy statement. Available at: https://www.who.int/publications/i/item/9789240042346. Accessed Sept 13, 2024.
5. Tsuyuzaki M, Igari H, Okada N, Suzuki K. Role of CD8 T-cell in immune response to tuberculosis-specific antigen in QuantiFERON-TB Gold Plus. J Infect Chemother 2020;26:570-4. [CrossRef]
6. Can Sarınoğlu R, Sili U, Eryuksel E, Olgun Yildizeli S, Cimsit C, Karahasan Yagci A. Tuberculosis and COVID-19: an overlapping situation during pandemic. J Infect Dev Ctries 2020;14:721-5. [CrossRef]
7. McQuaid CF, Vassall A, Cohen T, Fiekert K, White RG. The impact of COVID-19 on TB: a review of the data. Int J Tuberc Lung Dis 2021;25:436-46. [CrossRef]
8. World Health Organization. Number of COVID-19 cases reported to WHO. Available at: https://covid19.who.int/. Dec 9, 2024.
9. World Health Organization. Global tuberculosis report 2019. Available at: https://www.who.int/publications/i/item/9789241565714. Accessed Sept 13, 2024.
10. Sargin G, Şentürk T, Ceylan E, Telli M, Çildağ S, Doğan H. TST, QuantiFERON-TB Gold test and T-SPOT.TB test for detecting latent tuberculosis infection in patients with rheumatic disease prior to anti-TNF therapy. Tuberk Toraks 2018;66:136-43. [CrossRef]
11. Pai M, Denkinger CM, Kik SV, Rangaka MX, Zwerling A, Oxlade O, et al. Gamma interferon release assays for detection of Mycobacterium tuberculosis infection. Clin Microbiol Rev 2014;27:3-20. [CrossRef]
12. Dilektasli AG, Erdem E, Durukan E, Eyüboğlu FÖ. Is the T-cell-based interferon-gamma releasing assay feasible for diagnosis of latent tuberculosis infection in an intermediate tuberculosis-burden country? Jpn J Infect Dis 2010;63:433-6. [CrossRef]
13. Metin Timur Ö, Tanir G, Öz FN, Bayhan Gİ, Aydin Teke T, Tuygun N. Comparison of QuantiFERON-TB gold in-tube test with tuberculin skin test in children who had no contact with active tuberculosis case. Tuberk Toraks 2014;62:116-21. [CrossRef]
14. Camlar SA, Makay B, Appak O, Appak YC, Esen N, Günay T, et al. Performance of tuberculin skin test and interferon gamma assay for the diagnosis of latent tuberculosis infection in juvenile idiopathic arthritis. Clin Rheumatol 2011;30:1189-93. [CrossRef]
15. Erol S, Ciftci FA, Ciledag A, Kaya A, Kumbasar OO. Do higher cut-off values for tuberculin skin test increase the specificity and diagnostic agreement with interferon gamma release assays in immunocompromised Bacillus Calmette-Guérin vaccinated patients? Adv Med Sci 2018;63:237-41. [CrossRef]
16. Petruccioli E, Chiacchio T, Navarra A, Vanini V, Cuzzi G, Cimaglia C, et al. Effect of HIV-infection on QuantiFERON-plus accuracy in patients with active tuberculosis and latent infection. J Infect 2020;80:536-46. [CrossRef]

17. Binay UD, Fincancı M, Fersan E, Karakeçili F. Comparison of Tuberculin Skin Test (TST) and T-SPOT.TB Tests for Diagnosis of Latent Tuberculosis Infection (LTBI) in HIV-infected patients. [Article in Turkish]. Mikrobiyol Bul 2019;53:388-400. [CrossRef]
18. Karatas Togral A, Muştu Koryürek Ö, Şahin M, Bulut C, Yağci S, Ekşioğlu HM. Association of clinical properties and compatibility of the QuantiFERON-TB Gold In-Tube test with the tuberculin skin test in patients with psoriasis. Int J Dermatol 2016;55:629-33. [CrossRef]
19. Hatemi G, Melikoglu M, Ozbakir F, Tascilar K, Yazici H. Quantiferon-TB Gold in tube assay for the screening of tuberculosis before and during treatment with tumor necrosis factor alpha antagonists. Arthritis Res Ther 2012;14:R147. [CrossRef]
20. Çekiç C, Aslan F, Vatansever S, Topal F, Yüksel ES, Alper E, et al. Latent tuberculosis screening tests and active tuberculosis infection rates in Turkish inflammatory bowel disease patients under anti-tumor necrosis factor therapy. Ann Gastroenterol 2015;28:241-6.
21. Comstock GW, Livesay VT, Woolpert SF. The prognosis of a positive tuberculin reaction in childhood and adolescence. Am J Epidemiol 1974;99:131-8. [CrossRef]
22. Kim KH, Kang JM, Ahn JG. Low-dose steroids are associated with indeterminate QuantiFERON-TB Gold In-Tube assay results in immunocompetent children. Sci Rep 2021;11:6468. [CrossRef]
23. Makarenko VV, Al-Turkmani MR, Rao LV. Clinical variables associated with indeterminate QuantiFERON®-TB Gold assay results: role of pre-incubation delay. Int J Tuberc Lung Dis 2018;22:1429-34. [CrossRef]
24. Erdem HA, Şanlıdağ G, Çınar E, Yaşar M, Pullukçu H, Taşbakan MS, et al. Friend or foe? evaluation of BCG vaccine and latent tuberculosis infection effect in patients diagnosed with COVID-19 infection. [Article in Turkish]. Mikrobiyol Bul 2021;55:300-10. [CrossRef]
25. Gao Y, Liu M, Chen Y, Shi S, Geng J, Tian J. Association between tuberculosis and COVID-19 severity and mortality: a rapid systematic review and meta-analysis. J Med Virol 2021;93:194-6. [CrossRef]