Discordance between Two Interferon-Gamma Release Assays in the Diagnosis of Latent Tuberculosis Infection in Healthcare Workers

Hiroshi Fujiwara,† Tomoyasu Nishimura†, Osamu Ikemoto,† Yaoko Takano,‡ Akiko Sakai‡, Naomi Kondo‡, Kazuko Ohtake§, Shuji Oguchi‡, Nobuko Shimizu‡, Ayako Shibata‡, Masatoshi Wakuji,¶ Mitsuhiro Murata‡, Masaaki Mori§, Satoshi Iwata† and Naoki Hasegawa**

†Center for Infectious Diseases and Infection Control, Japan
‡Department of Laboratory Medicine, Keio University School of Medicine, Tokyo, Japan
§Central Clinical Laboratory, Keio University Hospital, Tokyo, Japan
¶Health Center, Kanagawa University, Kanagawa, Japan

Corresponding author: Naoki Hasegawa, Center for Infectious Diseases and Infection Control, Keio University School of Medicine, 35 Shinanomachi, Shinjuku-ku, Tokyo 160-8582, Japan, Tel: +81-3-5363-3710; Fax: +81-3-5363-3711; E-mail: n-hasegawa@z8.keio.jp

These authors contributed equally to this work.

Abstract

Background: Interferon-gamma release assays (IGRAS) more accurately diagnose Mycobacterium tuberculosis (Mtb) infection than the tuberculin skin test. To prevent outbreaks in medical facilities, early detection and treatment of Mtb infection (including latent tuberculosis infection (LTBI)) is important in healthcare workers. Therefore, the IGRAS have considerable utility for Mtb infection control in medical facilities. In Japan, two IGRAS are commercially available, QuantiFERON®-TB Gold In-Tube assay (QFT-GIT) and T-SPOT®.TB (T-SPOT). However, it remains unclear if diagnostic yields of LTBI by both IGRAs are equivalent in healthcare workers.

Methods: We performed both QFT-GIT and T-SPOT simultaneously in healthcare workers with a high risk of LTBI (excluding active tuberculosis) between December 2012 and February 2013.

Results: Among 313 subjects (excluding 2 cases with indeterminate T-SPOT), 6 (1.9 %) and 12 (3.8 %) were QFT-GIT positive and T-SPOT positive, respectively. There was no significant concordance of results between the QFT-GIT and the T-SPOT (p=0.064 and Kappa=0.43, 95% confidence interval 0.062-0.78). Among 10 discordant cases between two IGRAs, 8 cases had IGRAs’ results near the cutoff values.

Conclusion: Without a diagnostic gold standard for LTBI, it is difficult for us to further assess which test is more accurate and suitable for the diagnosis of LTBI. However, to diagnose LTBI of healthcare workers with IGRAs’ results near the cutoff values, we should consider clinical context, such as contact level, as well as the results of IGRAS.

Keywords: Interferon-Gamma Release Assay; Latent Tuberculosis Infection; Healthcare worker

Abbreviations

IGRA: Interferon-Gamma Release Assay; Mtb: Mycobacterium tuberculosis; LTBI: Latent Tuberculosis Infection; QFT-GIT: QuantiFERON®-TB Gold In-Tube assay; T-SPOT: T-SPOT®.TB; TST: Tuberculin Skin Test; JSTB: Japanese Society for Tuberculosis; PBMCs: Peripheral Blood Mononuclear Cells; CDC: Centers for Disease Control and Prevention

Introduction

In Japan, approximately 20,000 people develop tuberculosis per year, and the incidence rate is approximately 16 per 100,000 people, which is 5 times that of the USA. Unfortunately, Japan has not taken yet its place among low incidence countries. Tuberculosis is a contagious, air-borne disease with the possibility of outbreaks of infection. In particular, medical facilities are at high risk for the outbreak of Mycobacterium tuberculosis (Mtb) infection, in part because of the population of immunocompromised patients. To prevent outbreaks of Mtb infection, patients with latent tuberculosis infection (LTBI) or active tuberculosis should be identified and treated with anti-tuberculosis drugs immediately in medical facilities.

Conventionally, the tuberculin skin test (TST) was widely used for indirect detection of Mtb infection, but TST use was limited by the high false-positive rate caused by bacilli Calmette-Guerin vaccination in Japan. The interferon-gamma release assays (IGRAS), which measure interferon-gamma produced by effector T lymphocytes stimulated with Mtb-specific antigens, are new assays developed this century for detection of Mtb infection. While chest X-ray and sputum culture test are useful to detect active pulmonary tuberculosis, the IGRAS are more accurate than the TST in detection of LTBI [1]. At the present time, IGRAS are recommended for LTBI identification by the Japanese Society for Tuberculosis (JSTB) [2] and two IGRAS are commercially available in Japan, QuantiFERON®-TB Gold In-Tube assay (QFT-GIT, Qiagen, Hilden, Germany) and T-SPOT®.TB (T-SPOT, Oxford Immunotec, Abingdon, UK). However, it remains unclear if diagnostic yields of LTBI by both IGRAS are equivalent in healthcare workers. To evaluate the consistency of two tests in...
diagnosis of LTBI, we performed both QFT-GIT and T-SPOT in subjects with a high risk of LTBI (excluding active TB).

**Methods**

**Study population**

Between December 2012 and February 2013, QFT-GIT and T-SPOT were simultaneously performed in 315 healthcare workers from Keio University Hospital, following approval from the Institutional Ethics Committee of the Keio University School of Medicine (2012-343). 71 healthcare workers were TB contacts and 244 were in the high risk group with possible Mtb contact. In total, there were 208 women and 107 men aged 20-65 years (mean 35). The healthcare workers were 129 nursing staff, 76 medical doctors, 42 medical processors, 37 pathological department staff, 17 laboratory staff, and 14 radiation technologists. The high risk group with possible Mtb contact was defined as the healthcare workers in the departments with the possibility of exposure to patients with active pulmonary TB or Mtb.

**The interferon-gamma release assays**

Two blood samples were collected simultaneously to perform the tests in-house according to the manufacturers’ instructions. Briefly, blood samples for QFT-GIT were incubated within 4 hours after blood collection, and blood samples for T-SPOT were collected and after 16-32 hours were treated with T-cell Xtend® (Oxford Immunotec, Abingdon, UK) before processing in the assay. The QFT-GIT and T-SPOT results were simultaneously performed in 315 healthcare workers from Keio University Hospital, following approval from the Institutional Ethics Committee of the Keio University School of Medicine (2012-343). 71 healthcare workers were TB contacts and 244 were in the high risk group with possible Mtb contact. In total, there were 208 women and 107 men aged 20-65 years (mean 35). The healthcare workers were 129 nursing staff, 76 medical doctors, 42 medical processors, 37 pathological department staff, 17 laboratory staff, and 14 radiation technologists. The high risk group with possible Mtb contact was defined as the healthcare workers in the departments with the possibility of exposure to patients with active pulmonary TB or Mtb.

**Statistical methods**

The concordance of results between the QFT-GIT and the T-SPOT were evaluated by the calculation of the kappa value and test of coincidence. A P value <0.05 was considered statistically significant.

**Results**

Among 313 subjects (excluding 2 cases with indeterminate T-SPOT), 6 (1.9 %) and 12 (3.8 %) were QFT-GIT positive and T-SPOT positive, respectively (Table 1). There was no significant concordance of results between the QFT-GIT and the T-SPOT (p=0.064 and Kappa=0.43, 95% confidence interval 0.082-0.78). Table 2 shows the characteristics of the 10 cases with discordant results between the two tests (2 cases with QFT-GIT positive/T-SPOT negative and 8 cases with QFT-GIT negative/T-SPOT positive).

### Table 1: Comparison of QFT-GIT results and T-SPOT results

| QFT-GIT | T-SPOT results | Interpretaion | Age (Years) | Sex | Occupation | Group | Interpretation | Antigen | Mitogen | Nil | Interpretation | ESAT-6 | CFP-10 | Mitogen | Nil |
|---------|----------------|--------------|-------------|-----|------------|-------|----------------|---------|---------|-----|--------------|--------|--------|---------|-----|
| positive | 1              | High risk    | 45          | M   | MD         | Positive | 4.55 | 8.15 | 1.96 | Negative | 0 | 0 | 336 | 0 |
| negative | 2              | High risk    | 28          | M   | MD         | Positive | 0.9 | 9.72 | 0.05 | Negative | 1 | 1 | 412 | 0 |
| positive | 3              | High risk    | 43          | M   | MD         | Negative | 0.74 | 9.13 | 0.06 | Positive | 12 | 0 | 666 | 0 |
| negative | 4              | High risk    | 29          | F   | NS         | Negative | 0.19 | 11.87 | 0.39 | Positive | -1 | 8 | 350 | 2 |
| positive | 5              | High risk    | 43          | F   | LS         | Negative | 0.18 | 10.65 | 0.06 | Positive | 28 | 13 | 686 | 0 |
| positive | 6              | Contact      | 43          | F   | NS         | Negative | 0.14 | 12.52 | 0.07 | Positive | 9 | 0 | 528 | 0 |
| positive | 7              | High risk    | 24          | F   | NS         | Negative | 0.17 | 11.47 | 0.02 | Positive | 1 | 7 | 533 | 0 |
| positive | 8              | High risk    | 51          | M   | MD         | Negative | 0.05 | 8.82 | 0.05 | Positive | 6 | 7 | 595 | 0 |
| positive | 9              | High risk    | 37          | F   | PS         | Negative | <0.00 | 8.14 | 1.24 | Positive | 0 | 7 | 255 | 0 |
| positive | 10             | High risk    | 26          | F   | NS         | Negative | <0.00 | 9.31 | 0.06 | Positive | 0 | 6 | 400 | 0 |

1: M, Male; F, Female; 2: MD: Medical doctor; NS: Nursing staff; LS: Laboratory staff; PS: Pathological department staff; 3: Contact: Tuberculosis contacts, High risk: The high risk group with Mycobacterium tuberculosis (Mtb) contact; 4: The interferon gamma concentration in plasma from blood stimulated with Mtb-specific antigens (ESAT-6, CFP-10 and TB7.7) minus Nil; 5: The interferon gamma concentration in plasma from blood incubated without antigen; 6: The greater number of spots resulting from stimulation of peripheral blood mononuclear cells (PBMCs)
Table 2: The characteristics of 10 cases with the discordance of results between QFT-GIT and T-SPOT

Discussion

Our study showed that the positive rate of two IGRAs was approximately 3%. Although it is difficult for us to determine whether the specificity of two IGRAs in the diagnosis of LTBI is appropriate since there is no gold standard for LTBI, Harada et al. reported that the positive rate of the IGRA was 3.1% for comparatively-young Japanese healthcare workers similar to our subjects [3]. With reference to this, the specificity of two IGRAs seemed reasonable in our study. Our further analysis indicated that the concordance between the results of two IGRAs was moderate in according to the criteria for the strength of agreement beyond chance for various ranges of kappa value [4]. Previous reports have highlighted differences in sensitivity and specificity in active tuberculosis between the QFT-GIT and the T-SPOT [5,6]. The cross-sectional comparison study among military recruits was performed to assess the agreement between T-SPOT and QFT-GIT for LTBI in USA [7]. It showed kappa value was 0.39, which was similar to our result. Although based on the same principle, there are some methodological differences between the QFT-GIT and the T-SPOT. The QFT-GIT is an enzyme-linked immunosorbent assay-based, whole-blood test that uses three Mtb-specific antigens, ESAT-6, CFP-10 and TB7.7 in an in-tube format. The interferon-gamma concentration is measured for diagnosis. The T-SPOT is an enzyme-linked immunospot assay performed on separated and counted peripheral blood mononuclear cells (PBMCs), and the number of interferon-gamma producing T lymphocytes is measured for diagnosis. PBMCs are stimulated with two Mtb-specific antigens, ESAT-6 and CFP-10 [8]. The methodological differences between the two tests may explain their discordant results. In addition, the ability to produce interferon gamma may vary among the individuals since it would be dependent on the conditions of Mtb-exposure and host immunity. It may also contribute to the discordance between two IGRAs. Therefore it is reasonable that the different characteristics of the tests could occasionally create discrepant results for LTBI diagnosis. Without a diagnostic gold standard for LTBI, it is difficult for us to further assess which test is more accurate and more suitable for the diagnosis of LTBI.

Table 2 showed that the 10 cases had no common characteristics of sex, age, occupation or group, indicating that there were no specific characteristics contributing to the discordance between two IGRAs. The T-SPOT utilizes a borderline zone of 5, 6 or 7 spots as recommended by the Department of Health and Human Services Centers for Disease Control and Prevention (CDC) [9]. The QFT-GIT utilizes the borderline zone of interferon-gamma concentration, 0.10-0.35 IU/ml as recommended by the JSTB [10]. According to the guidelines of the CDC and the JSTB, there were 8 borderline cases (4 QFT-GIT borderline/T-SPOT positive, 1 QFT-GIT borderline/T-SPOT borderline and 3 QFT-GIT negative/T-SPOT borderline) among 10 cases with discordant results between the two tests. Several studies have raised concerns about the variability of IGRA’s results near the cutoff values [11,12]. Therefore, to diagnose LTBI precisely, Dorman et al. advised to confirm the interpretation of IGRA by repeating IGRA [13]. Taken together, we have to make a careful determination of IGRA’s results near the cutoff values.

Although previous reports showed that indeterminate results were significantly more frequent with QFT-GIT than with T-SPOT [5], there are 2 cases with indeterminate T-SPOT results and no cases with indeterminate QFT-GIT results in our study. Generally, indeterminate results of IGRA are associated with immunosuppression [14]. However, our cases with indeterminate T-SPOT results are more likely due to issues with technical issues or accuracy, since the QFT-GIT results of them argue against immunosuppression.

In conclusion, to evaluate the consistency of QFT-GIT and T-SPOT in the diagnosis of LTBI, both QFT-GIT and T-SPOT were performed simultaneously in healthcare workers. We found discordance in LTBI diagnosis between the two tests. When diagnosing LTBI of healthcare workers to prevent the outbreak, it is most important to find the cases with LTBI precisely and thoroughly, and prevent the development of tuberculosis immediately. From our perspectives, to diagnose healthcare workers with IGRA’s results near the cutoff values as LTBI, we should consider the clinical context (e.g. contact level, the infection rate of the contacts and so on) as well as the interpretation of IGRA.

Acknowledgement

We are grateful to Dr. Edy Yong Kim, Brigham and Women’s Hospital (MA, USA) for critical reading.

Financial/nonfinancial disclosures

The authors have reported to the Journal of Infectious Disease and Therapy that no potential conflicts of interest exist with any companies/organizations whose products or services may be discussed in this article.

Funding/SUPPORT

Assay kits and reagents were subsidized by Oxford Immunotec (T-SPOT.TB) and Japan BCG Laboratory (Quantiferon-TB). This study was supported by the Health Labour Sciences Research Grant in Japan (05-046-5131).

References

1. Diel R, Goletti D, Ferrara G, Bothamley G, Cirillo D, et al. (2011) Interferon-γ release assays for the diagnosis of latent Mycobacterium tuberculosis infection: a systematic review and meta-analysis. Eur Respir J 37: 88-99.
2. Prevention Committee of the Japanese Society for Tuberculosis; Treatment Committee of the Japanese Society for Tuberculosis (2014) Treatment guidelines for latent tuberculosis infection. Kekkaku 89: 21-37.
3. Harada N, Nakajima Y, Higuchi K, Sekiya Y, Rothel J, et al. (2006) Use in the diagnosis of LTBI, both QFT-GIT and T-SPOT were performed simultaneously in healthcare workers. We found discordance in LTBI diagnosis between the two tests. When diagnosing LTBI of healthcare workers to prevent the outbreak, it is most important to find the cases with LTBI precisely and thoroughly, and prevent the development of tuberculosis immediately. From our perspectives, to diagnose healthcare workers with IGRA’s results near the cutoff values as LTBI, we should consider the clinical context (e.g. contact level, the infection rate of the contacts and so on) as well as the interpretation of IGRA.

Acknowledgement

We are grateful to Dr. Edy Yong Kim, Brigham and Women’s Hospital (MA, USA) for critical reading.

Financial/nonfinancial disclosures

The authors have reported to the Journal of Infectious Disease and Therapy that no potential conflicts of interest exist with any companies/organizations whose products or services may be discussed in this article.

Funding/SUPPORT

Assay kits and reagents were subsidized by Oxford Immunotec (T-SPOT.TB) and Japan BCG Laboratory (Quantiferon-TB). This study was supported by the Health Labour Sciences Research Grant in Japan (05-046-5131).

References

1. Diel R, Goletti D, Ferrara G, Bothamley G, Cirillo D, et al. (2011) Interferon-γ release assays for the diagnosis of latent Mycobacterium tuberculosis infection: a systematic review and meta-analysis. Eur Respir J 37: 88-99.
2. Prevention Committee of the Japanese Society for Tuberculosis; Treatment Committee of the Japanese Society for Tuberculosis (2014) Treatment guidelines for latent tuberculosis infection. Kekkaku 89: 21-37.
3. Harada N, Nakajima Y, Higuchi K, Sekiya Y, Rothel J, et al. (2006) Screening for tuberculosis infection using whole-blood interferon-gamma and Mantoux testing among Japanese healthcare workers. Infect Control Hosp Epidemiol 27: 442-448.
4. Landis JR, Koch GG (1977) The measurement of observer agreement for categorical data. Biometrics 33: 159-174.
5. Ferrara G, Losi M, D’Amico R, Roversi P, Piro R, et al. (2006) Use in routine clinical practice of two commercial blood tests for diagnosis of tuberculosis immediately. From our perspectives, to diagnose healthcare workers with IGRA’s results near the cutoff values as LTBI, we should consider the clinical context (e.g. contact level, the infection rate of the contacts and so on) as well as the interpretation of IGRA.

Acknowledgement

We are grateful to Dr. Edy Yong Kim, Brigham and Women’s Hospital (MA, USA) for critical reading.

Financial/nonfinancial disclosures

The authors have reported to the Journal of Infectious Disease and Therapy that no potential conflicts of interest exist with any companies/organizations whose products or services may be discussed in this article.

Funding/SUPPORT

Assay kits and reagents were subsidized by Oxford Immunotec (T-SPOT.TB) and Japan BCG Laboratory (Quantiferon-TB). This study was supported by the Health Labour Sciences Research Grant in Japan (05-046-5131).

References

1. Diel R, Goletti D, Ferrara G, Bothamley G, Cirillo D, et al. (2011) Interferon-γ release assays for the diagnosis of latent Mycobacterium tuberculosis infection: a systematic review and meta-analysis. Eur Respir J 37: 88-99.
2. Prevention Committee of the Japanese Society for Tuberculosis; Treatment Committee of the Japanese Society for Tuberculosis (2014) Treatment guidelines for latent tuberculosis infection. Kekkaku 89: 21-37.
3. Harada N, Nakajima Y, Higuchi K, Sekiya Y, Rothel J, et al. (2006) Screening for tuberculosis infection using whole-blood interferon-gamma and Mantoux testing among Japanese healthcare workers. Infect Control Hosp Epidemiol 27: 442-448.
4. Landis JR, Koch GG (1977) The measurement of observer agreement for categorical data. Biometrics 33: 159-174.
5. Ferrara G, Losi M, D’Amico R, Roversi P, Piro R, et al. (2006) Use in routine clinical practice of two commercial blood tests for diagnosis of tuberculosis immediately. From our perspectives, to diagnose healthcare workers with IGRA’s results near the cutoff values as LTBI, we should consider the clinical context (e.g. contact level, the infection rate of the contacts and so on) as well as the interpretation of IGRA.
infection with *Mycobacterium* tuberculosis: a prospective study. Lancet 367: 1328-1334.

6. Pai M, Zwerling A, Menzies D (2008) Systematic review: T-cell-based assays for the diagnosis of latent tuberculosis infection: an update. Ann Intern Med 149: 177-184.

7. Mancuso JD, Mazurek GH, Tribble D, Olsen C, Aronson NE, et al. (2012) Discordance among commercially available diagnostics for latent tuberculosis infection. Am J Respir Crit Care Med 185: 427-434.

8. Moon HW, Hur M (2013) Interferon-gamma release assays for the diagnosis of latent tuberculosis infection: an updated review. Ann Clin Lab Sci 43: 221-229.

9. Mazurek GH, Jereb J, Vernon A, LoBue P, Goldberg S, et al. (2010) Updated guidelines for using interferon gamma release assays to detect *Mycobacterium tuberculosis* infection - united states, 2010. MMWR. Recommendations and reports : Morbidity and mortality weekly report. Recommendations and reports / Centers for Disease Control 59: 1-25.

10. Committees for the Tuberculosis Prevention of the Japanese Society for Tuberculosis (2011) [Practice guidelines for usage of QuantiFERON TB-2G test]. Kekkaku 86: 839-844.