

Article

The Efficiency of the GeneXpert Method Compared With Traditional Methods for Diagnosing TB

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Abstract: Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains a significant global health concern, particularly due to its high prevalence in the lungs, accounting for approximately 70% of cases. While vaccines have alleviated the impact of TB, it remains highly contagious through airborne transmission from infected individuals. Other forms of TB, such as those affecting lymphatic glands or bones, are non-contagious. The distinction between latent TB infections and active, contagious forms highlights the importance of public health interventions. This study aims to explore the transmission dynamics, focusing on prevention strategies to mitigate airborne spread. Using a case study approach, the research analyzes infection patterns, underscores the need for vigilant contact management, and emphasizes the importance of vaccines and protective measures in preventing TB outbreaks. The findings suggest that early diagnosis and proper management can significantly reduce transmission, offering practical implications for TB control.

Keywords: Tuberculosis, Disease, Contagious, Care, Cure

1. Introduction

When it comes to tuberculosis disease, the question is always the bacterium from which the disease developed, thus determining the size of the bacterium, the volume and location of the bacterium. So first the place where this bacterium has multiplied is located and then it is diagnosed through medical methods. This can happen after a few months or years after the infection, since the multiplication of this bacterium is slow. It should be emphasized that tuberculosis bacteria can start to develop in one place, for example in the lungs, but it can also penetrate into other organs or places. This penetration of the bacterium can be done through the blood, specifically through the blood vessels and that, for example, in the lymphatic glands, the central nervous system, bones, etc. These forms of tuberculosis are not contagious. It should be emphasized that this bacterium is dangerous for children and people with weakened immunity.

Based on the past that tuberculosis was an incurable disease, today it is curable if it is treated correctly and in time, i.e. in the first stages of the onset of the disease, since if it is treated in the last stages, it is more difficult to get treatment and healing the disease. If the question arises when a tuberculosis can be contagious? Then the answer is that lung tuberculosis is more likely to be transmitted from the infected person to others, it does not only happen when the virus is in the lungs and has progressed so much that the sick person coughs up tuberculosis bacteria. So only in the phase of multiplying the amount of the virus can the sick person transmit tuberculosis and infect other people.

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2. Materials and Methods

The methodology for the research on diagnosing tuberculosis (TB) focuses on a comparative analysis between traditional methods and the GeneXpert MTB/RIF diagnostic method. This study involved analyzing clinical samples from suspected TB patients using both traditional diagnostic methods—such as microscopy, culture, and staining techniques—and the more advanced GeneXpert method. Traditional methods, while effective, have limitations in terms of sensitivity, time, and labor, whereas GeneXpert provides a faster, automated alternative capable of detecting *Mycobacterium tuberculosis* and its resistance to rifampicin. The samples were processed through these techniques, and the results were compared for accuracy, sensitivity, specificity, and predictive values. GeneXpert, an automated PCR-based test, offered a faster diagnosis and was evaluated in both pulmonary and extrapulmonary TB cases.

The study's methodology also includes cross-referencing GeneXpert results with real-time PCR and droplet digital PCR (ddPCR) methods, ensuring a comprehensive understanding of its diagnostic efficacy. The collected data from various international studies were incorporated to enhance the robustness of the analysis. This methodological approach allowed the study to evaluate the rapid diagnostic capability of GeneXpert in resource-limited settings and its applicability compared to traditional TB diagnostic techniques. Results were statistically analyzed to provide meaningful insights into the potential use of GeneXpert as a reliable tool for TB diagnosis, contributing to ongoing efforts to combat this infectious disease.

3. Results and Discussion

Tuberculosis (TB) continues to be a major global health problem, especially in low- and middle-income countries. Traditional TB diagnostic methods such as microscopy, culture techniques, acid-fast bacilli (AFB) staining, and traditional PCR are often limited by their sensitivity, time, and human resource requirements. The GeneXpert MTB/RIF diagnostic method is a rapid molecular test for the detection of *Mycobacterium tuberculosis* and its resistance to Rifampicin and thus represents an important advance in the diagnosis of TB. GeneXpert is an automated, closed-system PCR machine that enables rapid, cartridge-based testing with reagents for various diseases. By inserting a specific cartridge, it detects and amplifies the targeted genetic sequences (DNA or RNA) to confirm the presence or absence of a disease in a short time (Figure 1). Unlike traditional PCR testing, which requires specialized laboratories and skilled lab technicians, GeneXpert offers a cost-effective solution, thus simplifying the diagnostic process.

Studies comparing GeneXpert with traditional methods of TB diagnosis have given different results regarding sensitivity and specificity: A Turkish study with 2639 patients compared the results of the GeneXpert MTB/RIF test with the results of seeded cultures (BACTEC MGIT 960 and LJ -Löwenstein -Jensen medium). For pulmonary samples, the specificity, sensitivity, PPV (Positive Predictive Value) and NPV (Negative Predictive Value) were 80.8%, 98.8%, 84.9% and 98.4%, respectively. These values for non-pulmonary samples were 58.2%, 98.4%, 66.7% and 97.7%, respectively, suggesting that GeneXpert MTB/RIF is a useful method for the diagnosis of tuberculosis. [1]

Hillemann et al. in their study of 521 non-pulmonary samples, compared the results of the GeneXpert system with those of traditional liquid (MGIT 960) and solid culture (LJ) methods and found sensitivity and specificity of 77.3% and 98.2%, respectively. They stated that the GeneXpert system is a rapid and useful technique in the identification of non-pulmonary tuberculosis. [2]

Balaji et al. compared different staining techniques with GeneXpert and found that Ziehl-Neelsen staining has a sensitivity of 83.32% and a specificity of 100%, while fluorescent staining improves the sensitivity to 88.01% with the same high specificity. The GeneXpert test significantly increases sensitivity to 98.40% and maintains perfect

specificity, along with 100% positive and negative predictive values. Lowenstein-Jensen (LJ) medium: 100% sensitivity, specificity, positive predictive value and negative predictive value. Based on this study, the LJ field and the GeneXpert system are the most accurate techniques for diagnosing tuberculosis. [3]

A study involving 250 suspected TB patients found that solid culture grounds (the gold standard) detected TB in 12% of cases, while GeneXpert identified only 6.8% as positive. This suggests that although GeneXpert is faster, it may not always match the efficiency of traditional culturing methods. [4] A study by Kim et al. reports that the GeneXpert MTB/RIF method demonstrated a diagnostic sensitivity of 75.5%, while real-time PCR showed a higher sensitivity of 80% overall. For staining-positive samples, GeneXpert had a sensitivity of 93.8%, compared to 87.5% for real-time PCR, but for staining-negative samples GeneXpert's sensitivity dropped to 65.5%, which was lower than real-time PCR (75.9 %). [5]

Lapteva et al. analyzed sputum tests for MTB in 1355 TB patients and found that the GeneXpert MTB/RIF method showed comparable specificity to the culture method for infiltrative TB (78.4% vs. 80.9%, $p = 0.138$) and disseminated TB (75.0% vs. %, $p = 0.384$). GeneXpert outperformed sputum stain microscopy, with sensitivity in infiltrative TB at 78.4% vs. 49.8% ($p < 0.001$) and disseminated TB at 75.0% vs. 61.9% ($p = 0.009$) suggesting that GeneXpert facilitates early diagnosis, especially when clinical and radiological signs are unclear. [6] Recent studies have also evaluated newer techniques such as Droplet digital PCR (ddPCR) against GeneXpert, with ddPCR showing superior sensitivity (99%) compared to GeneXpert (64%) for detecting active TB cases. [7] This indicates a continuing evolution in diagnostic methodologies beyond traditional PCR.

Conclusion - The sensitivity and specificity of the GeneXpert MTB/RIF assay in the diagnosis of patients with pulmonary and extrapulmonary TB are comparable to the gold standard - the MTB culture method. Its ability to detect MTB and Rifampicin resistance at the same time makes it crucial for application especially in resource-limited countries, as it is rapid, easy to interpret and easy to use. However, GeneXpert MTB/RIF is mostly more expensive compared to traditional methods, so this aspect should also be considered. The GeneXpert method as well as new advances in diagnostics and treatment are what are expected to achieve WHO's objectives in eliminating TB as a public health risk.

As emphasized above, tuberculosis bacteria multiply very slowly and the development of an immunological reaction takes several years. Whether an infection has occurred can only be confirmed after eight weeks. In children under 12 years of age, the risk is greater, for the development of the most dangerous forms of tuberculosis. For this reason, for security reasons, a first test is done directly after the last contact and according to the test result, it is repeated after eight weeks.

Below I present some of the figures on how the TB virus is diagnosed:

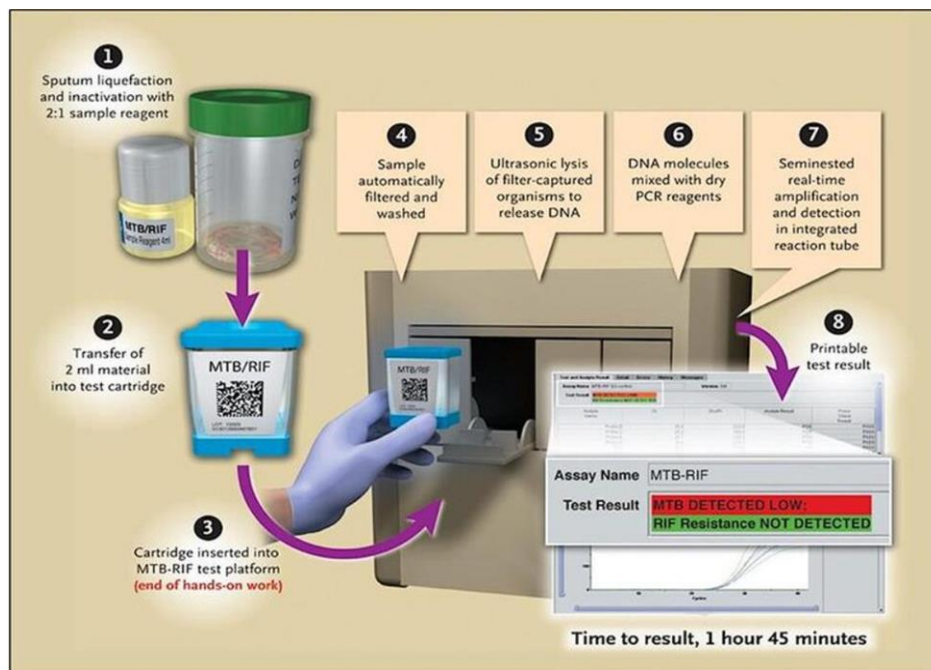


Figure 1. Procedura e kryerjes se procedurës së GeneXpert MTB/RIF në një mostër klinike [8]

GeneXpert MTB/RIF is a technology used for the rapid detection of Tuberculosis specifically in the lungs, and in addition to detection, it also determines the resistance of the virus to rifampicin (RFI) in pulmonary and extrapulmonary samples. [9]

This method is now used all over the world and has been in use since 2010, and thanks to this method, many people affected by the tuberculosis virus have been cured and rehabilitated. GeneXpert MTB/RIF is a second-generation test recently developed to increase sensitivity for the detection of tuberculosis. [10]

				Earliest time to MDR-TB diagnosis
Solid culture&DST	Microscopy (24 hours)	Solid culture (6-8 weeks)	1st line DST (3-4 weeks)	9-12 weeks
Liquid culture&DST	Microscopy (24 hours)	Liquid culture (2-3 weeks)	1st line DST (1-3 weeks)	3-5 weeks
Line Probe Assays e.g., HAIN test	Microscopy (24 hours)	If sputum smear positive, LPAs (24 hours)		1-2 days
Xpert MTB/RIF	If pulmonary specimen ~ 2 hours			~2 hours

Figure 2. Conventional methods compared with new methods of TB diagnosis

4. Conclusion

Tuberculosis, being a deadly disease, must be treated and provided with the maximum health care necessary for its treatment. Diagnosis is very necessary when it is done in the first stages of the disease. When a tuberculosis is diagnosed, the treating doctor, the treating doctor and the laboratory must show it to the canton doctor of the canton where the sick person lives. The canton doctor, the canton doctor decides, based on the results of the analyses, if an environmental analysis should be performed. This is the case when it comes to contagious pulmonary tuberculosis. If there is such a thing, then the specialized tuberculosis center of the responsible cantonal lung league is charged with the task of performing the environmental analysis. She comes into contact with the sick person. Together, a list of contact persons who have a risk of infection is prepared (Question 8). Normally these are family members, living partners, work or leisure colleagues. These people are then informed, and tested, if they have been infected. Based on the mentioned procedure, the patient who has been affected by this virus will have an easier time facing and also recovering from this disease since now the medical conditions are much better and more advanced than in the past. Therefore, we should be careful and interested in maintaining hygiene and maintaining our health, since if we notice in time something that does not go well with our health and report it to the doctor, then it is easier to recover than if we remain silent and the disease grows and it is more difficult to recover from that disease. So as a general practitioner I recommend that we be careful in food, activity and everything that is in favor of our health!

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