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Optimizing the Diagnosis of Tuberculous Pericarditis through the Use of GeneXpert MTB/RIF

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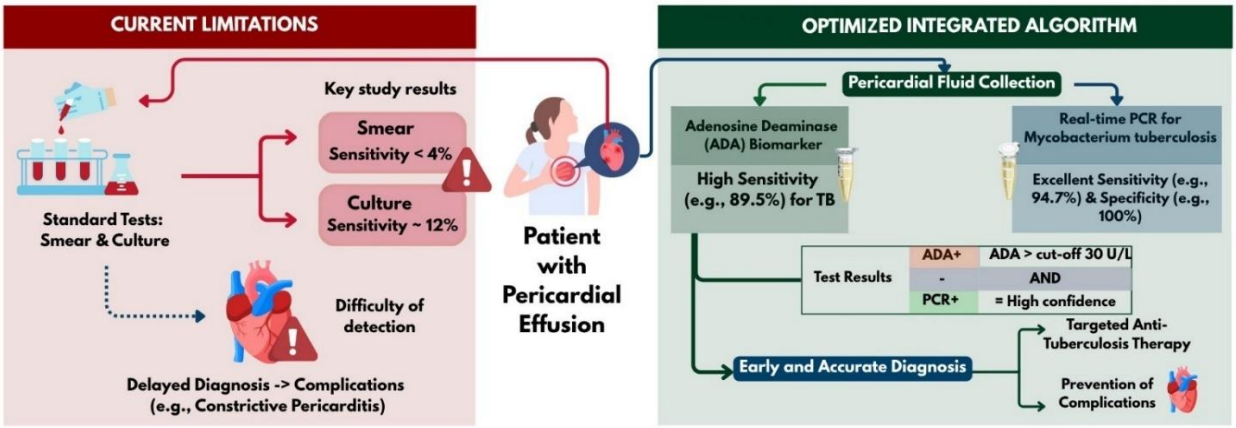
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Graphical abstract

This prospective study evaluated the GeneXpert MTB/RIF® test (Cepheid Inc., USA) for diagnosing pericardial tuberculosis (TBP) in comparison with culture, the reference method recommended by the Moroccan National Tuberculosis Control Program (PNLAT). Twenty-seven pericardial fluid samples collected over 36 months at Ibn Sina University Hospital, Rabat, were analysed using bacilloscopy, culture, and GeneXpert MTB/RIF. Microscopy showed no positive results, whereas GeneXpert MTB/RIF and culture yielded positivity rates of 14.81% and 11.11%, respectively; the assay also demonstrated 100% sensitivity and NPV, with 95.8% specificity and 75% PPV. These findings indicate that GeneXpert MTB/RIF is a rapid and reliable first-line diagnostic tool for pericardial tuberculosis, providing results much faster than culture.



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Abstract: This study evaluated the performance of the GeneXpert MTB/RIF® test (Cepheid Inc., USA) for detecting *Mycobacterium tuberculosis* and Rifampicin resistance in pericardial tuberculosis (TBP), compared to culture, the reference method recommended by the Moroccan National Tuberculosis Control Programme (PNLAT). Conducted prospectively over 36 months, the study analysed 27 pericardial fluid samples from suspected TBP cases at Ibn Sina University Hospital, Rabat. Conventional methods (bacilloscopy and culture) were compared to GeneXpert MTB/RIF. Microscopy showed no positive results, whereas GeneXpert MTB/RIF and culture yielded positivity rates of 14.81% and 11.11%, respectively. Most culture-positive samples were bacilloscopy-negative. The GeneXpert MTB/RIF assay showed 100% sensitivity and NPV, with 95.8% specificity and 75% PPV. No Rifampicin resistance was identified. The findings suggest that GeneXpert MTB/RIF is a rapid and reliable first-line diagnostic tool for pericardial tuberculosis and may replace smear microscopy and culture, which require prolonged incubation.

Keywords: Pericardial Tuberculosis, GeneXpert MTB/RIF, Molecular Diagnosis.

Introduction

Tuberculosis (TB) continues to represent a major global health concern, particularly in low- and middle-income countries [1]. In regions where the burden of both tuberculosis and human immunodeficiency virus (HIV) is high, mortality associated with TB remains alarmingly elevated, especially among individuals co-infected with HIV/AIDS [2].

In immunocompromised patients, this high mortality is largely attributed to the increased occurrence of disseminated and severe forms of extrapulmonary TB, such as tuberculous pericarditis (PTB) [3]. PTB is the most lethal manifestation of extrapulmonary TB. This form of TB is the leading cause of clinically significant pericardial effusion in TB-endemic developing countries, accounting for up to 90% of pericardial effusions in HIV-infected individuals and 50–70% in HIV-uninfected individuals [4].

Mortality rates from tuberculous pericarditis increase from 17% to 40% within six months after diagnosis [3], and PTB accounts for approximately 7% of hospital admissions for acute heart failure in Africa [5]. The incidence of PTB has progressively increased [6], and it is the most common cause of pericarditis in areas with a high incidence of tuberculosis [6,7]. Early and accurate diagnostic measures are essential for controlling fatal extrapulmonary tuberculous infections [8].

Despite this disease burden and associated mortality, the diagnosis of PTB remains difficult, mainly because of the lack of simple, rapid, accessible, and accurate diagnostic tests [3]. This difficulty arises from the fact that the amount of MTB in pericardial fluid is generally very low. This biological sample is usually paucibacillary, with diagnostic accuracy by culture and microscopic smear estimated at 50% and 5%, respectively [4].

In addition, MTB culture requires several weeks to provide results [9]. Consequently, the definitive diagnosis of PTB remains complex and is often delayed [10].

Recent studies have suggested that rapid initiation of anti-tuberculosis treatment may reduce mortality, making the search for new rapid diagnostic tests for PTB crucial [11]. To improve the prognosis of PTB, early diagnosis and antibacterial treatment are essential. Early diagnosis of PTB nevertheless remains difficult in many suspected cases [7]. Without prompt and effective treatment, PTB can lead to serious complications, such as constrictive pericarditis and even death [7].

Until 2018, Lowenstein-Jensen (LJ) culture was considered the gold standard for diagnosing tuberculous pericarditis, as early non-invasive diagnostic procedures, such as chest radiographs, revealed changes suggestive of tuberculosis in only 30% of cases, and echocardiography showed only a large sling-like projection of pericardial effusion, which is too nonspecific to indicate a

tuberculous aetiology [12,13]. Nevertheless, LJ culture is time-consuming and complex. It is therefore not recommended for routine use [14].

Other alternatives, such as histopathological examination, require invasive procedures and expertise available only in a limited number of medical centres. In addition, its sensitivity remains highly variable, ranging from 30% to 70% [15]. Histopathological examination is therefore not recommended as a routine test [16]. Currently, the Xpert MTB/RIF test is FDA-approved as a diagnostic test for pulmonary tuberculosis. This test detects members of the *Mycobacterium tuberculosis* complex and rifampicin resistance (RR) through nucleic acid amplification. It has proven useful in diagnosing pulmonary tuberculosis, with a sensitivity of 89% and a specificity of 99% [15].

The Xpert MTB/RIF test is a recent quantitative PCR assay that allows rapid diagnosis of *Mycobacterium tuberculosis* (MTB) and rifampicin resistance (RR), with results available in less than two hours [17]. WHO guidelines for the integration of the GeneXpert MTB/RIF test into the TB diagnostic process are based on its rapid results and proven performance, particularly its sensitivity and specificity for the diagnosis of both pulmonary and extrapulmonary TB [18].

The use of rapid molecular techniques for the diagnosis of tuberculosis is recognized by the World Health Organization as an essential element in tuberculosis control strategies, both for initial diagnosis and for monitoring disease progression [19].

Considering the good performance of Xpert MTB/RIF in the diagnosis of tuberculosis, the World Health Organization has recommended its use for the early diagnosis of tuberculosis since 2010 [20]. Xpert MTB/RIF is also applicable to extrapulmonary tuberculosis (EPTB), such as lymph node tuberculosis, and has demonstrated excellent diagnostic efficiency [21]. The application of Xpert MTB/RIF in the diagnosis of PTB offers unique advantages.

The objective of our study was to evaluate the performance of GeneXpert MTB/RIF in the diagnosis of pericardial tuberculosis (PTB) in a tuberculosis-endemic country, in order to assess the sensitivity and specificity of this molecular technique compared to culture, which constitutes the reference method (gold standard).

Patients and Methods

This retrospective study covered a period of 36 months and concerned pericardial fluid samples (n=27) collected between January 2020 and January 2023 from patients suspected of pericardial tuberculosis in the Cardiology Department of Ibn Sina University Hospital. These samples were received at the Bacteriology Laboratory of Ibn Sina University Hospital for the detection of MTB

using conventional methods (bacilloscopy and culture), as well as the molecular method using the GeneXpert MTB/RIF test.

Samples were cultured on Lowenstein-Jensen media and incubated at 37°C, with daily observation during the first week and twice-weekly observation for up to 8 weeks [22]. Smear microscopy was performed according to the Ziehl–Neelsen method, as recommended by the World Health Organization [23]. The GeneXpert assay was performed according to the manufacturer's Cepheid protocol (2009), allowing rapid detection of *M. tuberculosis* DNA and rifampicin resistance mutations in less than 120 minutes [24,17].

Results

Distribution of tuberculosis patients by age and sex

In this study, 27 patient samples were analysed, of which 4 were found to be positive using GeneXpert MTB/RIF, corresponding to a positivity rate of 14.81%. The mean age of tuberculosis patients was 29.75 ± 14.43 years, with ages ranging from 14 to 48 years. A male predominance was observed, representing 75% of cases, corresponding to 3 out of 4 patients (Table 1).

Table 1. Distribution of patients with PTB revealed by GX according to sex

Sex	Number of Patients (n)	Percentage (%)
Female	1	25
Male	3	75
Total	**4**	**100**
Male/Female Ratio	**03:01**	

Distribution of patients with PTB according to GeneXpert MTB/RIF detection levels

The results of this study on the molecular detection of pericardial tuberculosis (PTB) by GeneXpert MTB/RIF reveal that the majority of cases, representing 75% of patients, were identified at a low level (n=0), and only one case was detected at a medium level. This finding is explained by the very nature of this mycobacterial infection, which is often characterized by paucibacillary samples and a low bacillary load in pericardial specimens.

This particularity makes detection more complex and requires the use of sensitive techniques capable of identifying the infection even at low detection levels. These results therefore underline the importance of using appropriate and sensitive diagnostic methods for more accurate detection of this form of extrapulmonary tuberculosis

Comparison of GeneXpert MTB/RIF results versus Bacilloscopy and Culture

The positivity rates for microscopy, GeneXpert MTB/RIF, and culture were 0% (n=0), 14.81% (n=4), and 11.11% (n=3), respectively. Comparison of GeneXpert results with those of smear microscopy and culture revealed notable discrepancies in the diagnosis of pericardial tuberculosis.

Indeed, all samples were negative by smear microscopy, whereas 75% of samples were culture-positive but smear-negative, implying that the clinician would have had to wait several weeks for culture results.

Furthermore, only one specimen (25%) showed negative results for both culture and smear microscopy, suggesting that a physician could potentially miss a diagnosis of pericardial tuberculosis if relying solely on negative conventional laboratory tests, thus making early identification of this infection difficult. These findings highlight the importance of using GX, which provides more rapid and sensitive detection, particularly in cases where both smear microscopy and culture are negative.

Performance of GX in the diagnosis of pericardial tuberculosis (PTB)

The contribution of the GeneXpert MTB/RIF test to the diagnosis of pericardial tuberculosis (PTB) is illustrated by the results obtained in our study, which demonstrate notable performance of the test compared with culture (gold standard). Indeed, the negative predictive value (NPV) was 100%, indicating that all GeneXpert-negative cases were truly free from pericardial tuberculosis.

Sensitivity (Se) also reached 100%, meaning that the test was able to identify all forms of PTB in the analysed samples. Specificity (Sp) was 95.8%, highlighting the test's ability to exclude uninfected cases. The positive predictive value (PPV) was 75%, indicating that a positive test result was associated with a 75% probability that the patient truly had PTB, thus reinforcing the reliability of this diagnostic method.

Finally, the Kappa index of 0.886 reflects good agreement between the results of GeneXpert MTB/RIF and those of the reference test (culture), indicating satisfactory performance in the context of this molecular diagnosis (Table 2).

Rifampicin resistance (RR) cases revealed by GX

The results of rifampicin resistance (RR) testing by GeneXpert MTB/RIF on the analysed pericardial fluid samples revealed no cases of resistance (n=0). All samples showed full susceptibility to rifampicin, confirming the absence of drug-resistant pericardial tuberculosis (RR-PTB).

Table 2. Results of GX Performance in the Diagnosis of Pericardial Tuberculosis Compared to Culture (Gold Standard)

GX in the Diagnosis of PTB	Positivity Rate (%)	RR (%)	NPV (%)	PPV (%)	Se (%)	Sp (%)	Kappa
Our study – Morocco (Rabat)	14.81 (n=4)	0 (n=0)	100	75	100	95.8	0.886

GX: GeneXpert MTB/RIF; **RR:** Rifampicin Resistance; **NPV:** negative predictive value; **PPV:** positive predictive value; **Se:** sensitivity; **Sp:** specificity

Discussion

Pericardial tuberculosis (PTB) accounts for approximately 1–8% of all new TB cases [25]. Similar to extrapulmonary tuberculosis (EPTB), PTB is also paucibacillary, making early diagnosis more difficult [4]. Delayed diagnosis or misdiagnosis leads to more severe clinical outcomes in PTB [3]. Conventional acid-fast bacilli (AFB) tests do not provide sufficiently high diagnostic performance to enable early and rapid diagnosis of PTB. There is therefore an urgent need for early, rapid, and direct detection methods for *Mycobacterium tuberculosis* (MTB) in order to reduce the risk of serious adverse events associated with PTB.

Nucleic acid amplification tests (NAATs), which directly detect nucleic acids from pathogenic bacteria, are widely used for the detection of pathogens such as tuberculosis [26]. NAATs are increasingly valued for their efficiency and accuracy in the early diagnosis of infectious diseases [27]. The Xpert MTB/RIF test is currently the most commonly used NAAT for the diagnosis of tuberculosis. This test detects MTB DNA through an automated real-time polymerase chain reaction and provides results in less than two hours [28].

Xpert MTB/RIF has excellent diagnostic efficacy for pulmonary tuberculosis (PTB) as well as extrapulmonary tuberculosis (EPTB). The World Health Organization also recommends the use of Xpert MTB/RIF for the early diagnosis of PTB, tuberculous meningitis, and lymph node tuberculosis [15,29]. This test is therefore used for the early diagnosis of PTB.

According to the national guidelines of the Ministry of Health and Social Protection for the diagnosis and management of extrapulmonary tuberculosis, certain forms of tuberculosis, such as neuromeningeal tuberculosis (TMN) or pericardial tuberculosis (PTB), may have serious consequences and compromise the patient’s prognosis. These forms require early detection and appropriate treatment in order to prevent severe complications and improve the chances of recovery [30].

Frequency of pericardial tuberculosis (PTB)

In this study, the positivity rate for pericardial tuberculosis (PTB) using the GeneXpert MTB/RIF (GX) test was 14.81%. This result lies within the lower range of rates reported in the literature, although it remains higher than those described in previous studies. For example, the studies by Diallo *et al.* [31] and Ullah *et al.* [41] reported no PTB positivity by GX (0%), which may be explained by differences in the study populations or in the diagnostic methods used [46] (Table 3).

Other studies have reported lower positivity rates, such as those by Saeed *et al.* [36] and Allahyartorkaman *et al.* [39], with rates of 10.16% and 10.83%, respectively. Slightly higher rates were observed in studies such as that of Mahmood *et al.* [43], which reported a rate of 11.30%. In comparison, studies by Toure *et al.* [32] and Khan *et al.* [38] reported higher positivity rates, reaching 20% and 20.69%, respectively. At the upper extreme, some recent studies reported much higher positivity rates, such as those by Yu *et al.* [42,45], which found rates of 47.37% and 61.11%, respectively [46] (Table 3).

These results suggest that the diagnostic performance of GeneXpert may vary according to the specific characteristics of the study population, the diagnostic criteria, and the methodologies employed. Our study nevertheless shows a trend similar to that reported in more recent studies, such as that of Xu *et al.* [35], which reported a rate of 25.71%, highlighting a general tendency towards improved PTB detection by GeneXpert. These differences in positivity rates may also be influenced by the evolution of diagnostic protocols and improvements in biological sampling and MTB detection technologies [46] (Figure 1).

Despite intensive efforts by the National Tuberculosis Control Programme (PNLAT) in Morocco, which have led to improvements in disease management and control, TB cases continue to be reported, particularly extrapulmonary tuberculosis (EPT), the frequency of which is steadily increasing. This worrying trend also affects pericardial tuberculosis (PTB), the incidence of which appears to be rising, especially among patients *without associated pulmonary tuberculosis.* This situation considerably complicates the laboratory diagnosis of PTB, as the absence of obvious pulmonary signs makes early identification of the disease more difficult (Figures 2, 3 and 4).

Table 3. Comparative Evaluation of GeneXpert MTB/RIF in the Diagnosis of Pericardial Tuberculosis (PTB) [31-45].

N°	Author Name	Publication Year	City/Country	n	Positive Samples	RR	NPV (%)	PPV (%)	Se (%)	Sp (%)
—	Our study	2025	Morocco (Rabat)	27	14.81% (n=4)	0% (n=0)	100	75	100	95.8
1	Diallo *et al.* [31]	2022	Senegal (Ziguinchor)	3	0% (n=0)	–	–	–	–	–
2	Toure *et al.* [32]	2017	Senegal (Dakar)	5	20% (n=1)	–	–	–	–	–
3	Pandie *et al.* [33]	2014	South Africa (Cape Town)	13	–	–	86.6	100	63.8	100
4	Yu *et al.* [34]	2017	China (Zhejiang)	27	44.44% (n=12)	0% (n=0)	66.7	100	70.6	100
5	Xu *et al.* [35]	2020	China (Zhejiang)	105	25.71% (n=27)	14.81% (n=4)	83.3	96.3	66.7	98.5
6	Saeed *et al.* [36]	2017	Pakistan (Lahore)	128	10.16% (n=13)	23.08% (n=3)	95.6	100	72.2	100
7	Sharma *et al.* [37]	2014	India (New Delhi)	20	–	–	83	50	25	94
8	Khan *et al.* [38]	2018	Pakistan (Peshawar)	29	20.69% (n=6)	–	86	100	86	100
9	Allahyartorkaman *et al.* [39]	2019	Iran (Tehran)	120	10.83% (n=13)	–	97.3	66.6	40	99.1
10	Theron *et al.* [40]	2014	South Africa (Cape Town)	131	35.11% (n=46)	–	–	–	46	94
11	Ullah *et al.* [41]	2017	Pakistan (Peshawar)	12	0% (n=0)	–	100	100	100	100
12	Yu *et al.* [42]	2022	China (Zhejiang)	18	61.11% (n=11)	–	87.9	68.8	61.1	91.1
13	Mahmood *et al.* [43]	2018	Pakistan (Sheikhupura)	115	11.30% (n=13)	–	95.6	100	72.2	100
14	Gopalaswamy *et al.* [44]	2021	India (Tamil Nadu)	–	–	–	–	–	60	88
15	Yu *et al.* [45]	2020	China (Zhejiang)	19	47.37% (n=9)	–	–	–	64	100

Note: PTB = pericardial tuberculosis; *n* = number of samples analysed, RR = rifampicin resistance; NPV = negative predictive value; PPV = positive predictive value; Se = sensitivity; Sp = specificity.

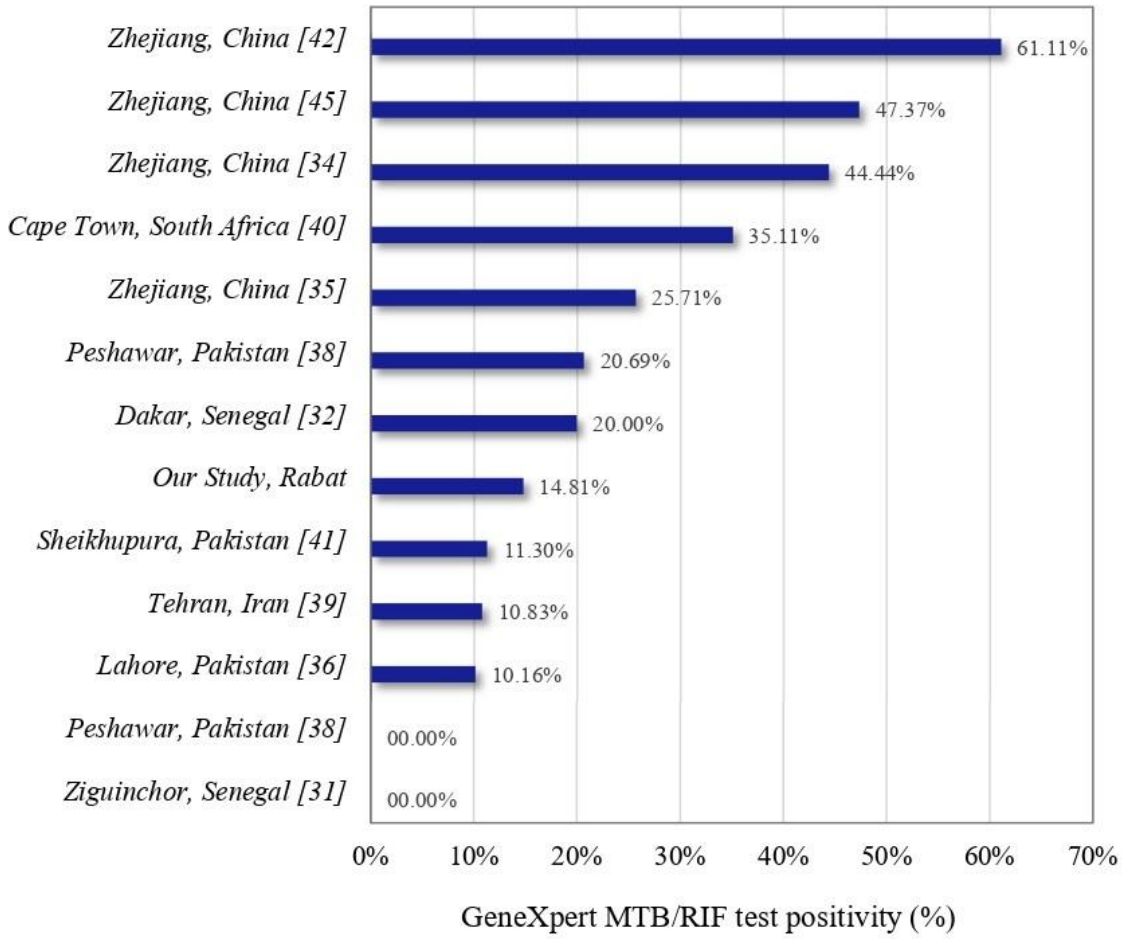
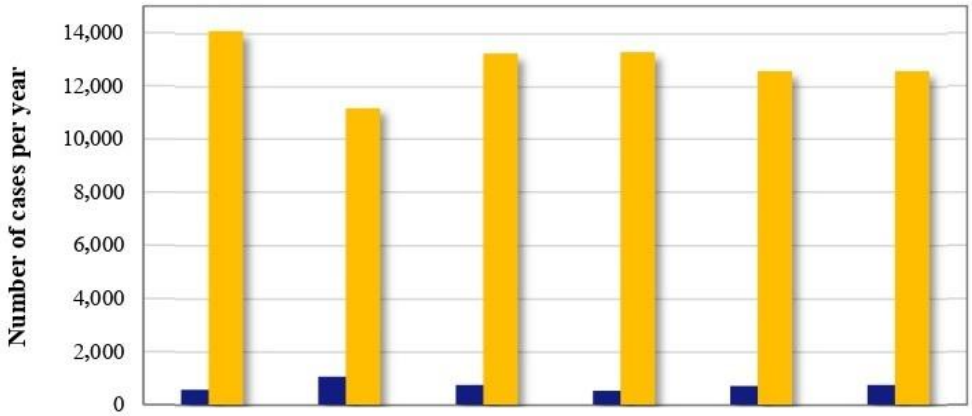
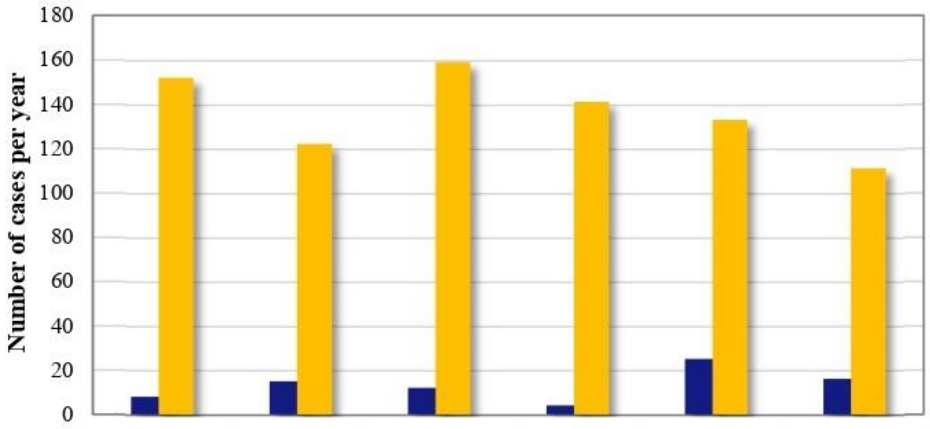


Figure 1. Comparison of GeneXpert MTB/RIF positivity rates for PTB diagnosis across different countries (Table 3)



	2016	2017	2018	2019	2020	2021
Associated with TP	556	1,053	738	521	708	737
Not associated with TP	14,055	11,152	13,215	13,259	12,548	12,550

Figure 2. Number of cases of Extra-pulmonary Tuberculosis (EPT) in Morocco from 2016 to 2021 **[47]**



	2016	2017	2018	2019	2020	2021
Associated with TP	8	15	12	4	25	16
Not associated with TP	152	122	159	141	133	111

Figure 3. Number of cases of tuberculous pericarditis associated and not associated with tuberculosis Pulmonary disease in Morocco from 2016 to 2021 **[47].**

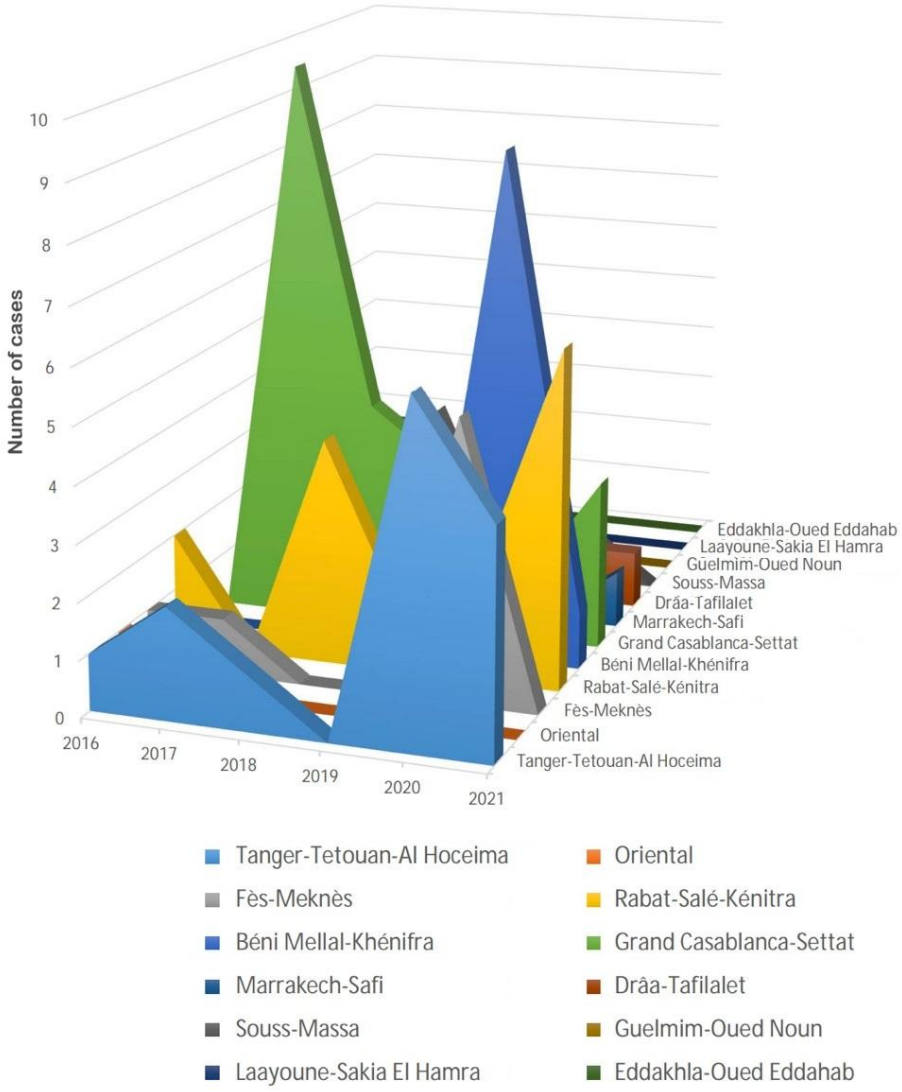


Figure 4. Trend profiles of tuberculous pericarditis cases by region from 2016 to 2021 [47]

Age and Sex of the Population with PTB

In our study, the mean age of patients with tuberculosis was 29.75 ± 14.43 years, with ages ranging from 14 to 48 years. A male predominance was observed, with men representing 75% of the study population, corresponding to three out of four patients. These results are consistent with the literature, which emphasizes that age and sex have biological and social effects that are often difficult to distinguish. Although the risk of developing primary disease is lower in children than in adults, adults are more likely to present severe forms affecting organs other than the lungs, such as tuberculous meningitis and pericardial tuberculosis [48].

According to the World Health Organization, the higher proportion of TB cases among men is consistent with data from national TB prevalence surveys, which indicate that the disease affects more men than women, with greater gaps in case detection and reporting among men. These findings are in agreement with our results, which also reveal a male predominance in our study population [49].

The Performance of GeneXpert MTB/RIF in the Diagnosis of PTB

Specificity (Sp)

In our study, the specificity of GX in the diagnosis of pericardial tuberculosis (95.80%) falls within the range of results reported in the literature. Similar studies, such as those by Gopalaswamy *et al.* [44] (88%), Yu *et al.* [42] (91.10%), Sharma *et al.* [37] (94%), and Theron *et al.* [40] (94%), reported slightly lower values, which may be explained by methodological differences or variations in endemicity rates among the populations studied (Table 3).

Other studies, such as those by Hu *et al.* [35] (98.50%), Allahyartorkaman *et al.* [39] (99.10%), as well as those by Pandie *et al.* [33], Yu *et al.* [34], Saeed *et al.* [36], Khan *et al.* [38], Ullah *et al.* [41], Mahmood *et al.* [43], and Yu *et al.* [45], reported a specificity of 100%, reflecting optimal results and probably a more selective population or particularly rigorous diagnostic methodologies. Overall, our result of 95.80% confirms the effectiveness of GX in the diagnosis of PTB and remains within a significant range compared to international studies (Figure 5).

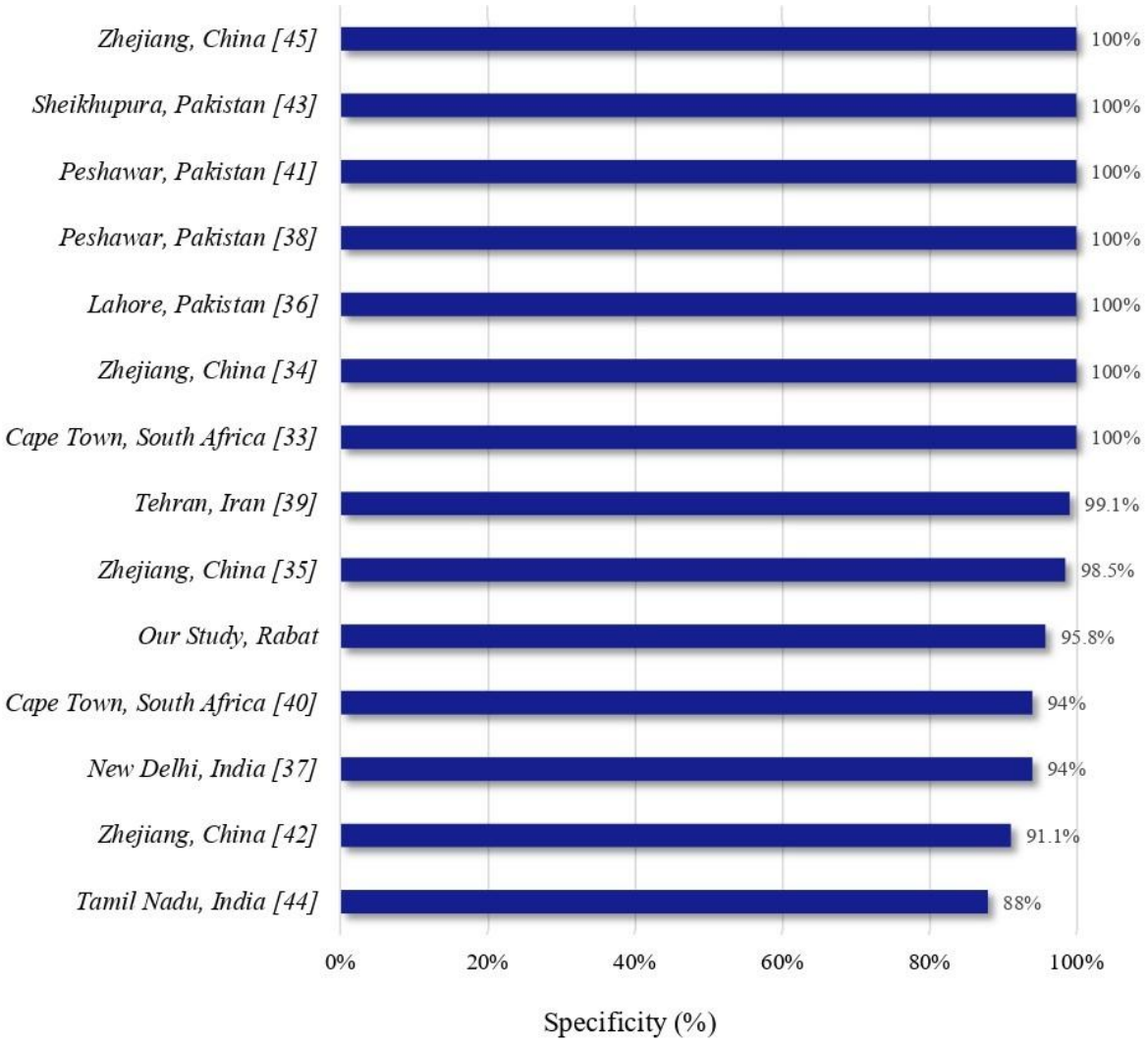


Figure 5. Comparison of GeneXpert MTB/RIF specificity (Sp) in the diagnosis of PTB across different countries (Table 3)

Sensitivity (Se)

In our study, the sensitivity (Se) of GX in diagnosing PTB (100%) is at the upper end of the values reported in the literature and is in perfect agreement with the best performances observed in previous studies. Earlier studies, such as those by Sharma *et al.* [37] (25%), Allahyartorkaman *et al.* [39] (40%), and Theron *et al.* [40] (46%), reported much lower results, reflecting the challenges associated with the early detection of tuberculosis in certain populations. Other studies, such as those by Gopalaswamy *et al.* [44] (60%), Yu *et al.* [42] (61.10%), and Pandie *et al.* [33] (63.80%), reported higher sensitivities, although still lower than that observed in our study [46] (Table 3)

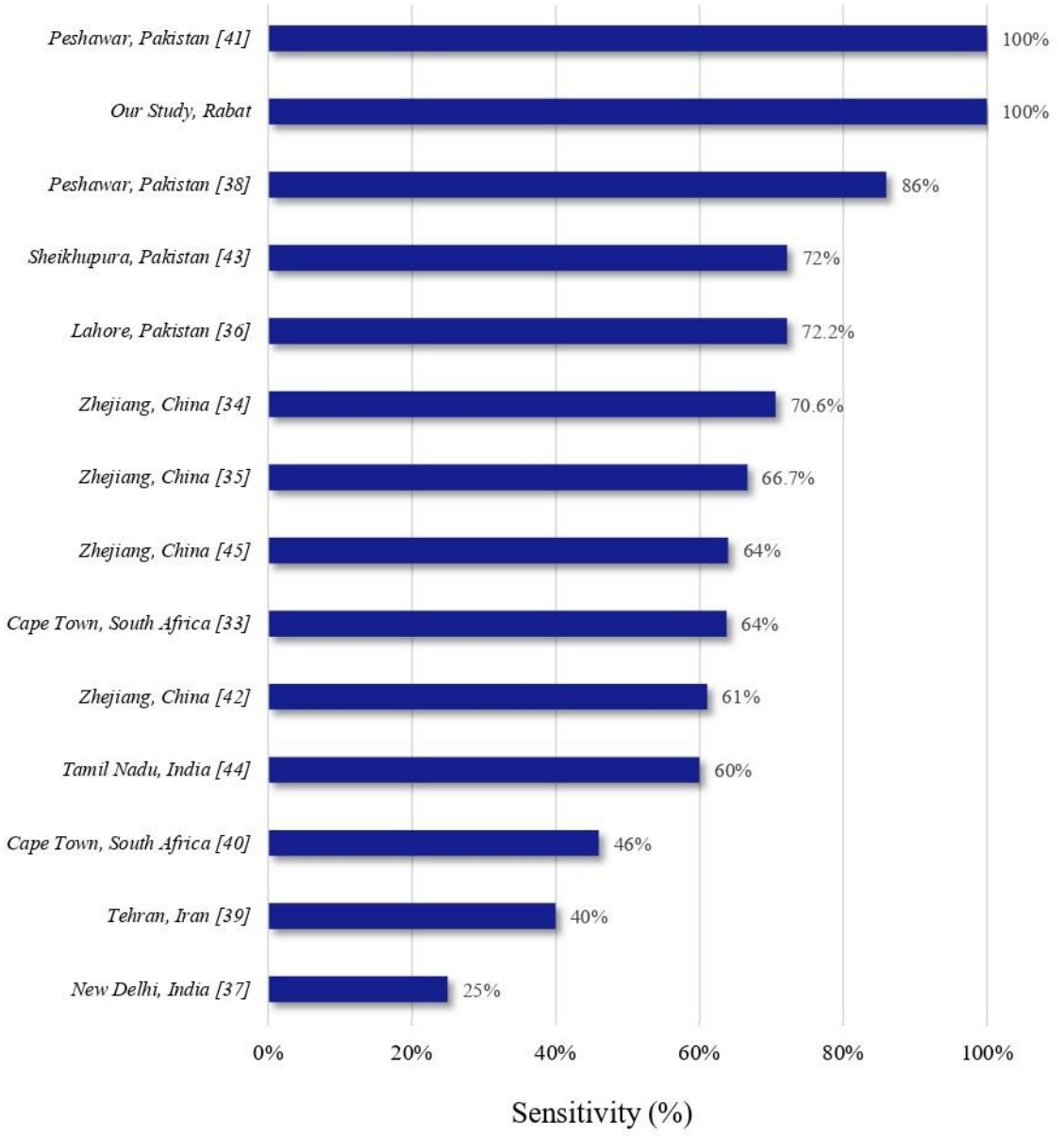


Figure 6. Comparative sensitivity (%) of GeneXpert MTB/RIF for the diagnosis of PTB across different countries (Table 3)

In particular, the studies by Hu *et al.* [35] (66.70%), Yu *et al.* [34] (70.60%), Saeed *et al.* [36] (72.20%), Mahmood *et al.* [43] (72.20%), and Khan *et al.* [38] (86%) demonstrated progressively improved results, with sensitivities increasing over the years alongside technological advances in diagnostic tests. It should be noted that the studies by Ullah *et al.* [41] and our study both reached the maximum sensitivity of 100%, which underlines the effectiveness of GX in the detection of tuberculosis (TB), including severe or atypical forms such as pericardial tuberculosis [46] (Figure 6).

Negative Predictive Value (NPV)

In our study, the negative predictive value (NPV) of GX in the diagnosis of pulmonary tuberculosis (100%) is among the highest reported in the literature and is consistent with the results obtained by Ullah *et al*. [41] (100%). The high NPV observed in our study indicates that GX is particularly effective in excluding the disease in patients without tuberculosis, thereby reducing the risk of false-negative results. Other studies, such as those by Yu *et al.* [34] (66.70%), Sharma *et al.* [38] (83%), and Hu *et al.* [35] (83.30%), reported lower NPVs, which may be related to differences in tuberculosis endemicity among the countries included in these studies [46] (Table 3).

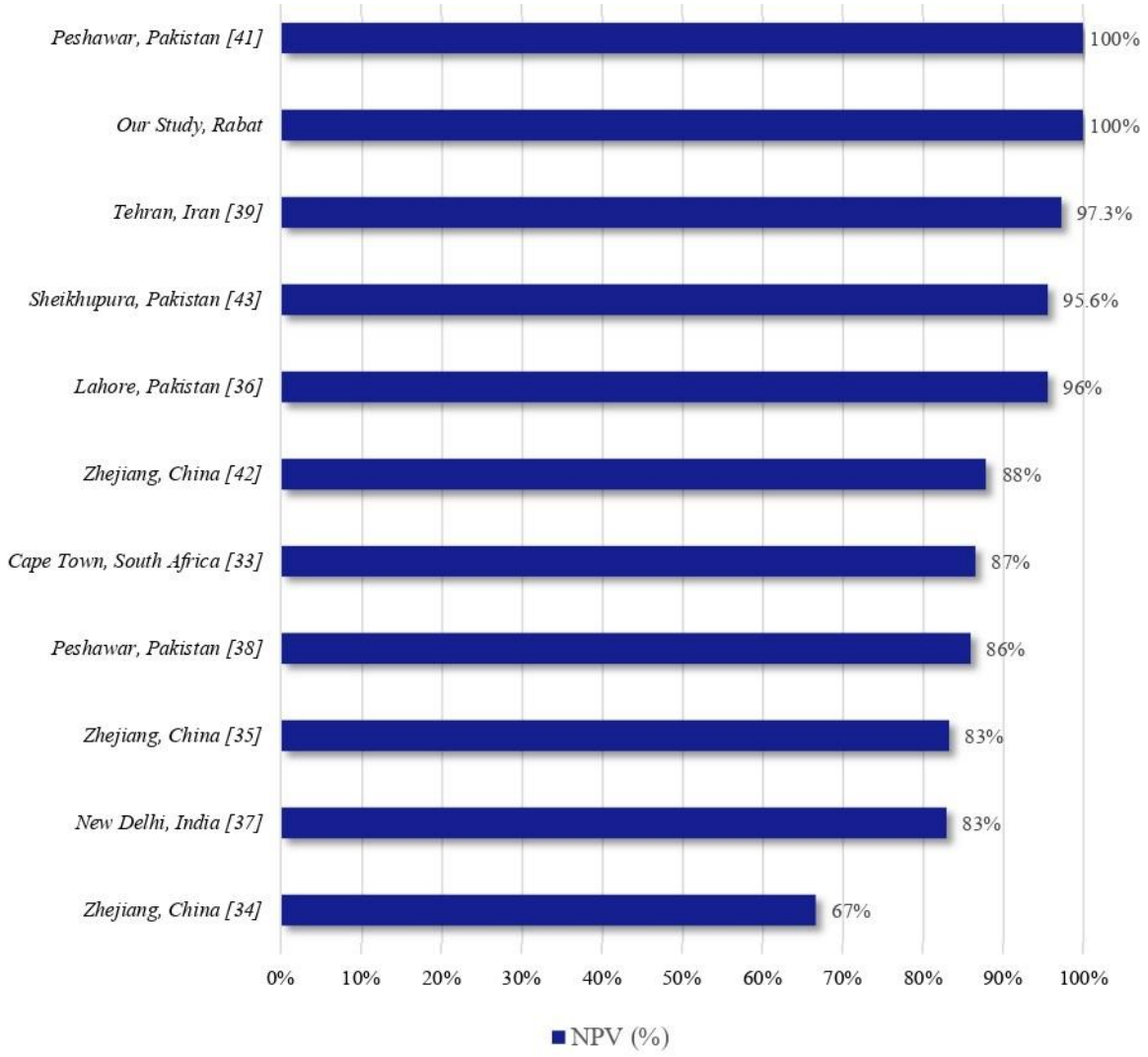


Figure 7. Comparison of GeneXpert MTB/RIF Negative Predictive Value (NPV) in the Diagnosis of PTB in Different Countries (Table 3)

On the other hand, several recent studies, such as those by Khan *et al.* [38] (86%), Pandie *et al.* [33] (86.60%), Yu *et al.* [42] (87.90%), as well as Saeed *et al.* [36] and Mahmood *et al.* [43] (95.60%), reported higher NPVs, although these values remained lower than those observed in our

study. These results reinforce the idea that GX, through its high specificity and sensitivity, offers excellent ability to identify non-TB patients, even in severe and complex forms of the disease such as pericardial TB.

In summary, our study confirms the crucial role of GX in the diagnosis of TB, with an optimal NPV, thereby ensuring reliable exclusion of negative cases [46] (Figure 7).

Predictive Value (PPV)

In our study, the positive predictive value (PPV) of GX in the diagnosis of pericardial tuberculosis (75%) falls within an intermediate range compared with other studies. Although this result is lower than those observed in some high-performing studies, such as Hu *et al.* [35] (96.30%), and several studies in which the PPV reached 100%, including those by Pandie *et al.* [33], Yu *et al.* [34], Saeed *et al.* [36], Khan *et al.* [38], Ullah *et al.* [41], and Mahmood *et al.* [43], it remains significantly higher than the values reported in other studies, such as those by Sharma *et al.* [37] (50%) and Allahyartorkaman *et al.* [39] (66.60%) [46] (Table 3) (Figure 8).

The PPV observed in our study, at 75%, demonstrates that GX is relatively effective in confirming tuberculosis in patients presenting symptoms compatible with the disease, although some variability remains according to the characteristics of the populations studied. Despite this variability, GX remains a powerful diagnostic test with a high PPV, indicating good ability to confirm positive cases, particularly in severe or complex forms of tuberculosis such as pericardial tuberculosis (Table 3).

Rifampicin Resistance (RTP – RR)

In our study, no cases of resistance were detected by the GX test in pericardial tuberculosis cases, which represents a favourable result compared to with other similar studies. Previous studies on pericardial tuberculosis have reported variable resistance rates, often depending on the region and treatment protocols. For example, studies conducted by Hu *et al.* [35] and Saeed *et al.* [36] reported resistance rates of 14.81% and 23.08%, respectively, in similar settings (Table 3).

In contrast, our study did not reveal any resistance, which may reflect the effectiveness of our treatment and patient-monitoring strategies. The absence of resistance observed in our study may also be explained by good control of treatment practices and rigorous patient follow-up, thereby reducing the risk of resistance development. This result underlines the importance of careful case management and adherence to anti-tuberculosis treatment, particularly in severe and complex forms such as pericardial tuberculosis.

The National Tuberculosis Control Programme (PNLAT) recommends the use of mycobacterial culture as the initial diagnostic test for pericardial samples in cases of suspected PTB [50]. Our results confirm this recommendation, with culture positivity observed in 75% of patients, highlighting its effectiveness.

It is important to note that these results are obtained only after several weeks of incubation, leading to delays in the management of this infection, particularly in cases of pericardial tuberculosis, which require early therapeutic intervention. This delay may have serious consequences for the patient's prognosis. In this context, the GX MTB/RIF test appears to be the method of choice, as it enables rapid and reliable diagnosis, thereby facilitating faster and more appropriate management of this form of extrapulmonary tuberculosis.

GeneXpert MTB/RIF remains an essential tool for the screening of tuberculosis (TB) and rifampicin-resistant tuberculosis (RR-TB), playing a key role on decisions regarding the initiation of treatment in cases of multidrug-resistant tuberculosis (MDR-TB) [51]. The World Health Organization recommended the use of the GeneXpert MTB/RIF test in 2010 for the diagnosis of pulmonary tuberculosis and in 2013 for the diagnosis of extrapulmonary tuberculosis [52].

Guidelines from the World Health Organization for the integration of the GeneXpert MTB/RIF test into the tuberculosis diagnostic process are based on its rapid results and proven performance, particularly its sensitivity and specificity for both pulmonary and extrapulmonary tuberculosis [53].

Limits of The Study

A major limitation of our study is the absence of confirmation of resistance cases detected by the GeneXpert test through a reference method such as GenoType MTBDR Plus. This limitation affects the accuracy of the results, particularly regarding the risks of false-positive and false-negative findings. In addition, the lack of data on patients' HIV status prevented assessment of the impact of TB–HIV co-infection on drug resistance.

Conclusion

The GeneXpert MTB/RIF test is superior to conventional methods (smear microscopy and culture) as an initial screening test for pericardial tuberculosis. Its good performance on smear- and culture-negative specimens demonstrates its effectiveness as a complementary diagnostic test. In the absence of limitations related to availability or cost, a single GeneXpert MTB/RIF test performed on a pericardial specimen could replace smear microscopy as the initial diagnostic method for PTB.

Our results support the use of the Xpert MTB/RIF test as the first-line diagnostic tool for PTB, providing clinicians with a rapid and reliable method for the appropriate and rational management of anti-tuberculosis treatment.

Compliance with Ethical Principles

We declare that this study was conducted in accordance with the ethical principles of the Declaration of Helsinki and international ethical standards for biomedical research concerning human participants.

Participant Consents

We certify that all participants or their legal representatives provided informed consent prior to inclusion in the study.

Confidentiality and Data Protection

The personal information of the participants was anonymized and handled confidentially, in accordance with applicable data protection laws and regulations.

Conflicts àf Interest

We declare that there are no conflicts of interest related to this study.

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