CBNAAT: A Novel Tool for Rapid Detection of MTB and Rifampicin Resistance

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ABSTRACT

Emergence of Multidrug resistant Tuberculosis (MDRTB) has become a significant obstacle for Tuberculosis (TB) control. Rifampicin (RIF) resistance is an important indicator of MDRTB. Rapid simultaneous detection of Mycobacterium Tuberculosis (MTB) and RIF resistance are very essential for effective disease management. CBNAAT (Cartridge Based Nucliec Acid Amplification Test) also known as Gene Xpert MTB/RIF assay is a novel diagnostic tool for detection of MTB and RIF resistance. To study the usefulness of CBNAAT for rapid detection of MTB and RIF resistance in MDRTB suspected cases. 1201 sputum samples were collected from MDRTB suspected cases including both new cases and previously treated cases. These were processed using Gene Xpert MTB/RIF assay. The results were statistically analyzed. Out of 1201 sputum samples, MTB was detected in 268 (22.31%) samples and RIF resistance was detected in 30 (2.49%) samples. 2 (33.33%) RIF resistant samples were from failures, 14 (12.17%) from Smear positive (S+) at diagnosis/retreatment case, 10 (12.65%) from follow up S+, 1 (0.11%) from HIV presumptive TB case. Combination of mutations i.e mutations associated with more than one probe was seen in all the 30 RIF resistant samples. Mutations at 5 different rpoB gene regions are 100% at 518-523, 96.66% at 507-511, 90% at 512-518, 86.66% at 523-529 and 43.33% at 529-533. Gene Xpert MTB/RIF assay is a good screening tool for diagnosis of MTB and detection of RIF resistance from MDRTB suspected cases within a shorter period.

Keywords
MDRTB, Rifampicin resistance, GeneXpert MTB/RIF.

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Introduction

According to the WHO Tuberculosis report 2015, India, Indonesia and China had the largest number of cases: 23%, 10% and 10% of the global total, respectively. Globally, an estimated 3.3% of new TB cases and 20% of previously treated cases have MDR-TB (WHO, 2015). The global priorities of TB control are early and improved TB case detection with the capacity to diagnose MDR TB. As the conventional laboratory methods are slow and cumbersome, Foundation for Innovative New Diagnostics (FIND) introduced cartridge-based nucleic acid amplification assay (Xpert MTB/RIF). It is a molecular test which is fully automated and detects M. tuberculosis as well as RIF resistance-conferring mutations directly from sputum samples within two
hours (WHO, 2011). This Gene Xpert was installed in our institute (Raichur institute of Medical Sciences) in March 2016 under Revised National Tuberculosis Control Programme (RNTCP) TB Xpert project supported by WHO-STOP TB partnership-UNITAID.

The surrogate marker for MDRTB is RIF resistance. The presence of mutations in 81 bp RIF resistance determining region (RRDR) of the rpoB gene, corresponding to codons 507–533 (Escherichia coli numbering system), which codes for a beta subunit of RNA polymerase of MTB is the genetic basis of RIF resistance (in approximately 95% cases) (Ramaswamy et al., 1998).

MDRTB burden and mutations responsible for drug resistance vary from country to country, region to region as per the studies conducted in diverse geographical areas (Purwar et al., 2011). But there is no enough information about this aspect from this part of Karnataka; therefore the study was conducted by using Xpert MTB/RIF assay.

Materials and Methods

The study was carried out in the RNTCP lab attached to Department of Microbiology, Raichur institute of Medical Sciences, Raichur, Karnataka, India. Sputum samples were received from various health centres of Raichur district (Sindhanoor, Sirawar, Maanvi, Yadgir, Devdurga, Raichur) and also referred cases from District TB centres (DTC), Antiretroviral (ART) centres. The study period was from March 2016 to August 2016. A total of 1201 sputum samples of suspected MDRTB cases including both new cases and previously treated cases were included. All the sputum samples were collected in special falcon tubes after through rinsing of the oral cavity with clean water. All the details of the patients like Name, Address, Age, Sex, History of contact, HIV status, Treatment received and Name of the referring centre were noted down.

Sputum specimens were processed by Xpert MTB/RiF assay (Cepheid-Sunnyvale-USA), as per the guidance document given by Central TB division, Government of India (RNTCP, 2013; RNTCP, 2012). rpoB gene of M. tuberculosis was extracted and amplified as it accounts for more than 95% of mutations associated with RIF resistance. It ensures high degree of specificity by usage of three specific primers and 5 unique molecular probes (WHO, 2014). The results can be distinguished as MTB detected, MTB not detected, RIF resistance detected; RIF resistance not detected; RIF resistance indeterminate; or invalid with the help of positive beacons and their detection timing, sample processing controls (WHO, 2013; Weyer et al., 2013). The manual steps involved in the assay are adding sample reagent to liquefy sputum and sample loading in the cartridge (RNTCP, 2013). The test procedure is made biosafe by tuberculocidal property of the assay’s sample reagent (WHO, 2013).

Results and Discussion

Out of 1201 sputum samples, MTB was detected in 268 (22.31%) samples and RIF was found to be resistant in 30 (2.49%). (Table 1)

MTB and RIF resistance was more commonly seen in sputum samples from males than females. 2(33.33%) RIF resistant samples were from failures, 14(12.17%) from S+ at diagnosis/ retreatment case, 10(12.65%) from follow up S+, 1(0.11%) from HIV presumptive TB case and 3(6.66%) from others. (Table 1)
Highest percentage of MTB and RIF resistance was seen in the age group of 51-60 yrs. Elderly had least RIF resistance. (Table 1)

38 (3.16%) samples showed “errors” and 28 (2.33%) samples showed “no results”. All these samples were retested, and valid results were obtained except in 3 (could not be processed due to insufficient material in the second sample also).

The combinations of mutations were seen in all the 30 RIF resistant samples detected by 5 different probes (A,B,C,D,E). In 5 samples, mutation was seen in all the probes. All the 30 (100%) had mutations at probe C, 29(96.66%) at probe A, 27(90%) at probe B, 26 (86.66%) at probe D, 13(43.33%) at probe E. Accordingly, the mutations at 5 different rpoB gene regions are 100% at 518-523, 96.66% at 507-511, 90% at 512-518, 86.66% at 523-529 and 43.33% at 529-533. (Table 1)

In this study, we observed RIF resistance which is a surrogate marker of MDR-TB in 2.49% of suspected cases of MDR-TB of raichur region. These findings are similar to reports from place nearby raichur ie from Krishna, Andhra Pradesh (2%) (Giridhar et al., 2014). However, higher prevalence of MDR-TB has been reported in other Indian studies (Lucknow 27.8% (Jain et al., 2014), New Delhi 17.9% (Singhal et al., 2015), and Central India 17%) (Desikan et al., 2014).

Our several findings are consistent with TB details: for example, males have higher MTB diagnostic rates compared to females (Balasubramanian et al., 2004). Elderly have lowest risk of MDR-TB compared to other age groups, may be due to reduced survival amongst those with TB infection (ICMR, 2012).

RIF resistance was most commonly seen in failures (33.33%) in this study. Other studies showed 23.47% from Kerala (Ganguly et al., 2015), 17% from South India (Santha et al., 2005).

Retreatment cases/smear positive at diagnosis was 12.17% among RIF resistant cases in this study. In a study by S K Sharma et al., (Sharma et al., 2011) drug resistance was found in 20% of Retreatment cases at diagnosis which is high compared to our study.

0.11% among RIF resistant cases was found to be HIV seropositive in our study. HIV seropositivity was observed by Deivanayagam et al., (Deivanayagam et al., 2002) in 4.42% of MDRTB patients.

The most common RRDR rpoB gene mutations were in the gene region 518–523, recognized by Probe C. But Mboowa et al., observed most common mutation in codon 531 (58%) followed by 513 (25%), 526 (8%), and 511 (8%) designed by probes E, B, D, and A. (Mboowa et al., 2014). Mani et al., reported that the codons most commonly involved in these mutations were 531 (53%) and 526 (19%) in a study from South India (Mani et al., 2001). The resistant mutants isolated more frequently in clinical practice have higher mean relative fitness and their prevalence depend on their ability to survive (Billington et al., 1999). Combinations of mutations (all the probes) were observed in all the 30 isolates of the RIF resistant samples in the present study. While, Singhal et al., found 6 strains (6/366) with more than one mutation (Singhal et al., 2015). Probably, mutations continue to arise due to the ability of MTB to adapt to drug exposure (Mani et al., 2001). The results were statically analyzed (p<0.0005).
Table 1: Demographic profile of study participants

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>% of N</th>
<th>TB</th>
<th>% (of row)</th>
<th>RIF resistance</th>
<th>% (of row)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Male</td>
<td>645</td>
<td>53.70%</td>
<td>197</td>
<td>30.54%</td>
<td>22</td>
<td>3.41%</td>
</tr>
<tr>
<td>Female</td>
<td>556</td>
<td>46.29%</td>
<td>71</td>
<td>12.76%</td>
<td>8</td>
<td>1.43%</td>
</tr>
<tr>
<td><strong>Age (yrs)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-30</td>
<td>315</td>
<td>26.22%</td>
<td>71</td>
<td>22.53%</td>
<td>10</td>
<td>3.17%</td>
</tr>
<tr>
<td>31-40</td>
<td>484</td>
<td>40.29%</td>
<td>92</td>
<td>19%</td>
<td>13</td>
<td>2.68%</td>
</tr>
<tr>
<td>41-50</td>
<td>260</td>
<td>21.64%</td>
<td>56</td>
<td>21.53%</td>
<td>1</td>
<td>0.38%</td>
</tr>
<tr>
<td>51-60</td>
<td>98</td>
<td>8.15%</td>
<td>34</td>
<td>34.69%</td>
<td>6</td>
<td>6.12%</td>
</tr>
<tr>
<td>&gt;61</td>
<td>44</td>
<td>3.66%</td>
<td>15</td>
<td>34.09%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td><strong>RNTCP MDR suspect criteria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1: Failure</td>
<td>6</td>
<td>0.49%</td>
<td>3</td>
<td>50%</td>
<td>2</td>
<td>33.33%</td>
</tr>
<tr>
<td>2: Retreatment case, S+ at 4th month</td>
<td>4</td>
<td>0.33%</td>
<td>4</td>
<td>100%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>3: Contact of known MDRTB case</td>
<td>1</td>
<td>0.08%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>4: S+ at diagnosis, retreatment case</td>
<td>115</td>
<td>9.57%</td>
<td>99</td>
<td>86.08%</td>
<td>14</td>
<td>12.17%</td>
</tr>
<tr>
<td>5: Any follow up S+</td>
<td>79</td>
<td>6.57%</td>
<td>65</td>
<td>82.27%</td>
<td>10</td>
<td>12.65%</td>
</tr>
<tr>
<td>6: Smear – at diagnosis, retreatment case</td>
<td>83</td>
<td>6.91%</td>
<td>20</td>
<td>24.09%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>7: HIV TB case</td>
<td>31</td>
<td>2.58%</td>
<td>9</td>
<td>29.03%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>8: HIV presumptive TB case</td>
<td>837</td>
<td>69.69%</td>
<td>56</td>
<td>6.69%</td>
<td>1</td>
<td>0.11%</td>
</tr>
<tr>
<td>11: Others*</td>
<td>45</td>
<td>3.74%</td>
<td>12</td>
<td>26.66%</td>
<td>3</td>
<td>6.66%</td>
</tr>
</tbody>
</table>

(Criteria 9: Presentation paediatric, Criteria 10: Presentation extrapulmonary, both are excluded from the study)

Need of nonstop power supply, Ambient temperature not exceeding 30°C, incomplete sensitivity for smear-negative TB, inability to detect resistance to isoniazid and other drugs, Biosafety measures comparable to smear microscopy, Waste disposal system for cartridges, Trained laboratory, Annual calibration of the Xpert modules are the few limitations with the CBNAAT (Vassall et al., 2011).

Small sample size is the limitation in this study. But data regarding prevalence of TB and its drug resistance status at national and
State level are the need of the hour. One more limitation of the study was that no gold standard was used for the comparison of Xpert MTB/RIF assay results.

In conclusion, Xpert MTB/RIF is a better screening tool for simultaneous detection of MTB and RIF resistance in a shorter period of time, and this could help improve early recognition of MDR-TB and prevention of its further transmission in raichur region of Karnataka. From this study we conclude that RIF resistance cases are found in significant no. of MDR TB suspects using CB NAAT (GeneXpert MTB/RIF). Most of the resistant patients are failure cases. HIV patients should also be screened for MDRTB. Although Xpert MTB/RIF assay tells about pattern of mutation in rpoB gene, DNA sequencing for detailed study is a must.

Acknowledgment

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Conflict of Interest: None to declare

References


Guidance document for use of Catridge Based-Nucleic Acid Amplification Test (CB-NAAT) under Revised National TB Control Programme (RNTCP) issued central TB division, directorate general of health services September 2013.


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