Sequence Analysis of Rifampicin Resistance Determining Region (RRDR) of *Mycobacterium tuberculosis*

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**ABSTRACT**

*Mycobacterium tuberculosis* has become the cause for one of the most dreadful disease which the mankind has ever known i.e. Tuberculosis. The organism holds the ability to infect multiple organs at a time resulting in multiple symptomatic presentations in pathogenic condition while in non-pathogenic condition, it can lay dormant and remain asymptomatic. The research work presented here aimed at sequencing of Rifampicin Resistance Determining Region (RRDR) of the *rpoB* gene present in phenotypically multidrug resistant *M. tuberculosis*. The findings showed that the major point of mutations to be present within this region was at codon 516, 526, and 531. Early diagnosis of multidrug resistance in any pathogen has become a prerequisite for proper treatment and efficient elimination of pathogenic organisms from the host with minimal toxicity. Similarly, understanding the mutation dynamics of target genes also help in novel drug design and discovery.

**Keywords:** Mycobacterium tuberculosis, rifampicin, rpoB, RRDR, sequence

**INTRODUCTION**

Tuberculosis (TB) has a serious clinical significance as it holds the record for being a disease responsible for causing morbidity and mortality for the longest time. Nepal and the corresponding developing nations suffer most, from the brute nature of the disease [1]. The bacterium responsible, *Mycobacterium tuberculosis*, normally resides in the lungs causing pulmonary tuberculosis; however, it is not delimited to other organs, hence in such cases called as extra pulmonary tuberculosis [2]. The pathogen is infectious and takes aerial mode for transfer. The bacterium presents clinical symptoms based upon its location such that the pulmonary cases are recognized by chronic cough, chest pain, weight loss and others [3].

Among the distinguished members of Mycobacteria, *M. tuberculosis* holds a particular interest due to its clinical significance in causing various types of tuberculosis. Tuberculosis, a malady as old as human civilization itself still holds an icy grip upon its victim despite the advances in treatment with vaccines and antibiotics [4]. Multidrug resistant *M. tuberculosis* (MDR – TB) is generally referred to that strain of Mycobacterium which has become resistant to both Rifampicin and Isoniazid.

**Mechanism of resistance for Rifampicin**

Resistance to rifampin arises due to mutations in the β subunit of RNA polymerase encoded by the gene *rpoB* [5]. This includes point mutations, deletions, and insertions [6]. This results in conformational changes that determine a low affinity for the drug and consequently the development of resistance [7]. Most mutations were determined to be restricted to an 81-bp core region and are dominated by single nucleotide changes, resulting in single amino acid substitutions, although in frame deletions and insertions also occur at lower frequencies. Changes in the codons Ser531 and His526 have been documented in more than 70% of the RIF-resistant isolates [8].
Figure 2. Agarose gel (2%) electrophoresis for PCR products amplified using MPB64 primers for confirmation of Mycobacterium samples. L1 – Ladder; L2 – L4: Sample No. 1 to 3

Figure 3. Agarose gel (2%) electrophoresis for PCR products amplified using gene specific primers for RRDR region of rpoB. L1 – Ladder; L2 – L10: Sample No. 1 to 9.

MATERIALS AND METHODS

DNA preparation

Twenty-four M. tuberculosis samples which were phenotypically determined as multiple drugs resistant by Drug Susceptibility Test were collected from Global hospital, Lalitpur, Nepal. DNA isolation from the lysate was performed using Accuprep DNA Purification Kit™.

Confirmation of Mycobacterium by MPB64 Primer

The purified DNA samples were confirmed to be that of Mycobacterium using MPB64 primers. The PCR was performed using the primer set MFP (5’-TCGCT GCCAGTCCGTCTTCC-3’) and MRP (5’-GTCCCTGCG GAGTTAGGGCA-3’). The PCR condition was set as initial denaturation at 95°C for 5 minutes followed by denaturation at 95°C for 45 seconds, 55°C for 45 seconds and extension at 72°C for 30 seconds for 35 cycles followed by final extension at 72°C for 10 minutes and hold at 4°C.

Primer for sequencing

rpoB gene specific primer was used as previously described by Fan et al. in 2003 [10]. The primer sequence covers the nucleotide sequence most prone for mutation and primarily involves the region responsible for rifampicin resistance. Hence, the region is commonly referred to as Rifampicin Resistance Determining Region (RRDR).

Sequencing

Preliminary analysis of the sequence obtained was done using Chromas Lite 2.1.1 followed by sequence alignment in the software MEGA 6.06 by Clustal W. The final sequence was then compared with the RNA polymerase β subunit (rpoB) gene of the M. tuberculosis (Accession No. L27989.1) sequence available at European Nucleotide Archive (European Molecular Biology...
RESULTS AND DISCUSSION

Confirmation of M. tuberculosis by PCR

The samples obtained were confirmed as that of M. tuberculosis by performing PCR with MPB64 primers. The confirmation was done as evident from presence of PCR products comparative to the band of approximately 240 bp visualized under UV as shown in Figure 1. Out of 24 samples subjected to PCR, 19 samples showed positive results. Although all 24 samples were identified as phenotypic MDR TB, the absence of bands in 5 samples could be due to loss of DNA during purification step resulting in false negative results. This is though hard to be determined as many samples despite of lacking visible band in the gel gives positive result during the PCR amplification. So, the next probable reason would be the degradation of DNA during storage causing loss of amplification. This could be due to improper storage condition. In conclusion, out of 24 samples gathered for this study, only 19 samples could be utilized for further down streaming processes.

Sequence analysis

A 537 bp region of DNA encompassing the RRDR of rpoB gene of M. tuberculosis was amplified using a gene specific primer which was subsequently utilized for sequencing (Figure 2). Analysis of the data obtained

Figure 5. Schematic diagram depicting the type and number of particular mutation as well as percentage of mutation occurring at codons 516, 526, and 531 in different samples when compared to standard sequence of the strain L27989.1. [9]

Table 1. Table showing the isolates with mutation in the specific codons as validated by the sequencing. The highlighted codons represent the mutation in the codons of the sample when compared with the standard sequence of the strain L27989.1.

| Sample No. | L27989.1 516 Codon/AA | L27989.1 526 Codon/AA | L27989.1 531 Codon/AA |
|------------|------------------------|------------------------|------------------------|
| 06r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 07r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 10r        | GAC/ Asp               | GAC/Asp                | TCG/Ser                |
| 11r        | GAC/ Asp               | GAC/Asp                | TCG/Ser                |
| 12r        | GAC/ Asp               | TAC/Tyr                | TCG/Ser                |
| 14r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 16r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 21r        | GAC/ Asp               | GAC/Asp                | TCG/Ser                |
| 24r        | GAC/ Asp               | TTC/Phs                | TCG/Ser                |
| 26r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 29r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 31r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 32r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 35r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 40r        | GAC/ Asp               | GCC/Gly                | TCG/Ser                |
| 43r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 45r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 46r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
| 49r        | GAC/ Asp               | CAC/His                | TCG/Ser                |
showed at least one mutation within the region. The results obtained were comparable to that done by Fan et al., whereby the authors observed that among the samples they procured, mutation was highly probable in the codon 531 [10].

In our study, mutations could be perceived only in the codons 516, 526 and 531 with highest percentage of mutation being observed at codon 531 (63.15%) followed by codon number 526 (21.05%) and 516 (15.78%) (Figure 3, 4, and 5). All of the mutations witnessed in this study come within the RRDR of the rpoB gene as has been observed in several of the studies previously done [11, 12].

The RRDR is considered to be a hotspot region bearing several mutations responsible for imparting resistance to Mycobacterium against the first line of drug, Rifampicin. Although all the samples showed mutation in the region being analysed, the resistance could not be solely attributed to the analysed region only and there might be mutations on the other sites as well. The analysis of full length gene of rpoB was not possible for our study; hence mutations might be present outside of the RRDR that could be contributing to varying degree of resistance against rifampicin. Further analysis of multidrug resistance M. tuberculosis needs to be carried to establish a correlation between the codon of mutation and the degree of resistance.

CONCLUSION

Sequence analysis of 19 samples showed mutation at three codons namely 516, 526, and 531. The mutation thus occurring possibly imparts bacterium with the ability to be resistant to the drug, rifampicin. Hence, for the timely diagnosis of the multidrug resistant Mycobacterium as well as improved prognosis for the patient, it is imperative to detect such cases at an early stage through accurate methods like sequencing.

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