

Comparison of Multiplex PCR and Acid fast and Auramine-Rhodamine staining for detection of Mycobacterium tuberculosis and nontuberculosis Mycobacteria in Paraffin-Embedded pleural and bronchial tissues with granulomatous inflammation and caseous necrosis

J Ghenaat, A Omid, K Ghazvini, H Ayatollahi, A Hossein Jafarian, M Erfanian, M Taghi Shakeri, M Bagheri, H Tavassolian

Citation

J Ghenaat, A Omid, K Ghazvini, H Ayatollahi, A Hossein Jafarian, M Erfanian, M Taghi Shakeri, M Bagheri, H Tavassolian. *Comparison of Multiplex PCR and Acid fast and Auramine-Rhodamine staining for detection of Mycobacterium tuberculosis and nontuberculosis Mycobacteria in Paraffin- Embedded pleural and bronchial tissues with granulomatous inflammation and caseous necrosis*. The Internet Journal of Microbiology. 2006 Volume 4 Number 1.

Abstract

Aim: The aim of this study was to compare the sensitivity and specificity of Acid fast and Auramine-Rhodamine staining and Multiplex PCR for the detection of Mycobacterium Tuberculosis complex and nontuberculosis Mycobacteria on formalin fixed paraffin embedded tissues (FFPE)

Material and Method: 40 cases of FFPE pleural and bronchial tissue with chronic granulomatous inflammation and caseous necrosis and 10 cases with bronchogenic carcinoma as controls were investigated. We designed a Multiplex PCR DNA amplification Method with two targets: 123bp DNA fragment from IS6110, which is present only in mycobacterium tuberculosis complex and 162bp DNA encoding Ag 85 complex which is present in all of mycobacteria. The FFPE also stained by Acid fast and Rhodamine-Auramine staining method.

Results: In 26 samples (65%) 123bp and 162bp DNA fragments were detected together. The 162bp fragment didn't detect alone. The sensitivity of PCR was 65% and the specificity was 100%.

11 cases were positive for Acid fast staining. There was 27.5% sensitivity and 100% specificity.

13 cases were positive for Rhodamine- Auramine staining (R-A-S) there was 32.5% sensitivity and 100% specificity.

All of the 10 controls were negative for 123bp and 162bp DNA fragments and for Acid fast and Rhodamine- Auramine staining.

Conclusion: Multiplex PCR is a sensitive, specific and rapid method for detection of mycobacterium tuberculosis in FFPE tissues.

INTRODUCTION

Despite longstanding efforts to conquer tuberculosis, this disease remains an expanding global health crisis with 1/86 billion infected people (1,2). Methods for the diagnosis of tuberculosis improved in recent years and several molecular techniques for its diagnosis have been introduced for clinical use. Molecular methods provide several advantages, including confirmation of the presence of M.tuberculosis within 1 to 3 day (2,3).

The use of DNA amplification for detection of M. tuberculosis in formalin. Fixed paraffin embedded tissue samples would be useful for patient's in whom diagnosis depends on tissue examination, rather than detection of M. tuberculosis in body secretion. (1,4)

The diagnosis of tuberculosis is largely based on conventional approaches, which rely on clinical features and the result of microscopy and culture. Culture methods are sensitive and specific but they are slow and take 2-6 wks (3,4). Unfortunately, there are frequent occasions when tissue

Comparison of Multiplex PCR and Acid fast and Auramine-Rhodamine staining for detection of Mycobacterium tuberculosis and nontuberculosis Mycobacteria in Paraffin- Embedded pleural and bronchial tissues with granulomatous inflammation and caseous necrosis

obtained by biopsy is not sent for culture because the diagnosis was not a clinical consideration before the report of findings on microscopic examination of the tissues. (6,13)

Acid fast and Rhodamine- Auramine staining are rapid and inexpensive methods for diagnosis tuberculosis but their sensitivity is low. The number of bacilli in tissue section stained with Acid- fast and Rhodamine- Auramine staining seems to be much lower than that expected from the sputum smear data or the patients condition. (35, 7)

Infection caused by nontuberculosis mycobacteria (NTM) are increasing in immunocompromised individuals. Effective therapeutic regimens are different for patients infected with M.tuberculosis or NTM. Therefore it is necessary to establish and evaluate PCR assay to differentiate between these two groups of mycobacteria.

In order to establish sensitive Multiplex PCR, we selected two DNA targets : insertion sequences 6110 (IS6110) genes which present in multiple copies in the M.tuberculosis genome and the gene encoding Ag 85 complex.

We also used Acid fast and Rhodamine- Auramine staining to evaluate the sensitivity of these methods and compare the results with Multiplex PCR.

MATERIAL AND METHODS

Forty formalin-fixed, paraffin-embedded (FFPE) specimens(20 pleural, 20 bronchial samples) with granulomatous inflammation and caseous necrosis were obtained from lung biopsy files at the Department of Pathology of Ghaem Hospital from January 2002 to June 2005. 2 pathologists confirmed that every section included granuloma with caseous necrosis. The patients were 17 to 78 years old. 23 were male and 17 were female. 10 FFPE specimens of patients with bronchogenic carcinoma considered as negative controls. FFPE samples from a patient with confirmed pulmonary tuberculosis were used as a positive control in each procedure.

Sample processing for Acid Fast and Auramine rhodamine staining:

5 Micron- thick sections from each paraffin block were cut with a microtome. The paraffin was removed by soaking the slides in xylene, and then the slides were transferred to Tris-EDTA. Containing decreasing concentration of ethanol. These smear were stained with Acid- fast and Auramine-

Rhodamine staining according to standard confirmed procedures(4).

We used fluorescence microscopy for A-R stain reporting. The results of Acid- fast and A-R staining were reported after viewing 100 fields according to table 1.

Figure 1

Table 1 :Guidelines for Reporting Smears for Acid-Fast Bacilli

Number of AFB with acid fast stain (1000x)	Number of AFB with A-R stain (450x)	REPORT
1-2/300F	1-2/70 F	Doubtful
1-9/100F	2-18 /50 F	1+
1-9/10F	4-36/10F	2+
1-9 F	4- 36/ F	3+
> 9/F	> 36/F	4+

DNA EXTRACTION

5 Micron- thick section were made from %10 FFPE. To prevent contamination, a fresh blade was used for each sample and the microtome overly was covered with a piece of tape changed for every sample and after processing each specimen it was subsequently cleaned with xylene and ethanol 100%.Paraffin was removed from the samples by adding 1 ml xylene, vortexing the mixture ,and incubating at 45°C for 15 minute; this was followed by 10 minute centrifugation at 14000 rpm. The supernatant was removed and discarded, a further 1 ml of xylene was added to the pellet and the procedure was repeated .To facilitates pelleting and hydration of sample 1cc of ethanol 100% was added. .After vortexing, the sample were pelleted by 10 minute centrifugation at 14000 rpm and the supernatant was removed. A further 1 ml of ethanol 100% was added to the pellet and the procedure was repeated .The supernatant was removed then the pellet was air dried .The samples were resuspended in 400 l of digestion buffer made up of 1/5cc Nacl 5M, 0/5 cc EDTA, 0/5cc Tween 20 and sterile water up

Comparison of Multiplex PCR and Acid fast and Auramine-Rhodamine staining for detection of Mycobacterium tuberculosis and nontuberculous Mycobacteria in Paraffin- Embedded pleural and bronchial tissues with granulomatous inflammation and caseous necrosis

to total volume of 100 ml .Then we add 40 l of proteinase k and the mixture was incubated at 37°C for 24 hours. The proteinase k was inactivated by incubating the samples at 100°C for 8 minute and then we centrifuged pellets at 12000 rpm for 5 minute and remove the supernatant which is ready to use.

DNA AMPLIFICATION BY PCR

2 sets of primer were used to amplify target DNA fragments: The primer pairs MD1- MD2 expected to amplify 162bp DNA fragment of antigen 85 complex and the primer pairs KD1- KD2 were expected to amplify 123bp fragment of insertion sequence 6110.The designation and sequence of these primers are given in table 2. The primers were synthesized and cartridge purified by Bioscience Ltd, Heslington ,York, England.

Figure 2

Table 2: The oligonucleotide sequence of primers used in Multiplex PCR

Oligoname	Oligonucleotide sequence	Base number
MD1	5'- ATC AAC AAC CCG GCG TTC CAG-3	21
MD2	5'- CGC CAG CTC GCT GGT CAG GA-3'	20
KD1	5'-CCT GCC AGC GTA GGC GTC GG-3'	20
KD2	5'-CTC GTC CAG CGC CGC TTC GG-3'	20

Each reaction mixture contain primer KD1, primer KD2, primer MD1, primer MD2, dNTP, 10xPCR buffer, MgCl₂, Taq DNA polymerase, water and 5 liter of purified DNA. in total volume of 50 l. Gene amplification was done by a thermal cycler. (Thouchgene, Gradient). Cycling consisted of denaturing at 94 for 45 sec, annealing at 68 for 60 sec and extension at 72 for 6 sec. The total process has 35 cycles. To avoid false positive, separate physical facilities were used for sample preparation, amplification and analysis of the amplified products, In addition positive and negative controls were included.

Aliquots of amplified samples were loaded on %2 agarose gels in Tris- Acetate- EDTA (TAE) buffer and subjected to electrophoresis in mini gel boxes for 30 minutes at 80 volts. The gel stained with ethidium bromide at 0/5 mg/mL was observed under ultraviolet light for specific DNA bands and photographed. The DNA bands were identified according to size by comparing with molecular weight marker (50bp DNA ladder) loaded in separate lane.

RESULTS

40 samples (20 from bronchial tissues and 20 from pleural tissues) from the patients with chronic granulomatous inflammation and caseous necrosis were studied, the patient's were 17-78 years old and 23 were male and 17 were female. 10 patient's with bronchogenic carcinoma as controls were investigated. We designed a multiplex PCR which targeted 123bp DNA fragment from IS6110, which is present in 10- 25 copies in organisms of the M. tuberculosis complex group is perhaps the most commonly used target for the molecular detection of MTC, and 162bp DNA encoding Ag 85 complex which is present in all groups of mycobacteria.

Thus in MTC group we detected 123bp and 162bp DNA fragments. In non tuberculosis mycobacterium complex only 162bp DNA fragment detected.

In 26 samples (%65) 123bp and 162bp DNA fragments together were detected.

The 162bp DNA fragment didn't detect alone (%0) .All of our 10 controls were negative for 123bp and 162 DNA fragment. (Table 3)

Figure 3

Table 3 :Result of Multiplex PCR for 123bp and 162bp Mycobacterial DNA fragment in pleual and bronchial tissue with caseous necrosis

	123bp fragment		162bp fragment	
	number	frequency	number	frequency
Negative	14	35	14	35
Positive	26	65	26	65
	40	100	40	100

The sensitivity of PCR was %65 and the specificity was %100. The positive predictive value of the test was %100 and the negative predictive value was %41, all of the negative samples were also negative for Acid fast and A-R staining.

11 cases were positive for Acid fast staining, 2 samples were

Comparison of Multiplex PCR and Acid fast and Auramine-Rhodamine staining for detection of Mycobacterium tuberculosis and nontuberculous Mycobacteria in Paraffin- Embedded pleural and bronchial tissues with granulomatous inflammation and caseous necrosis

+++ , 4 samples were ++ and 5 samples were +, 15 samples with negative AFS where PCR positive ,the sensitivity of AFS was %27/5 the specificity was %100 the PPV(positive predictive value) was %100 and NPV(negative predictive value) was %27 (Table 4).

Figure 4

Table 4: Result of Acid Fast and Auramine-rhodamine stain for detection of mycobacteria in pleural and bronchial tissue with caseous necrosis

	Auramine-rhodamin stain		Acid Fast stain	
	number	frequency	number	frequency
-	27	67/5	29	72/5
+	4	%10	5	%12/5
++	7	%17/5	4	%10
+++	2	%5	2	%5
total	40	%100	40	%100

13 cases were positive for A- R staining , 2 samples were +++, 7 samples were ++ and 4 samples were +, the A-R negative section included 13 PCR positive cases .The sensitivity of A-R staining was %32/5, the specificity was %100 the PPV was %100 and NPV was %28.5. (Table 4)

Figure 5

Figure 1: Detection of Multiplex PCR product of M. tuberculosis gene on polyacrylamide gel electrophoresis. The lane numbers are as follows: lane M marker of 50-bp ladder; lane 1,2,3, positive ; lane 4, negative; and lane 5, negative control.

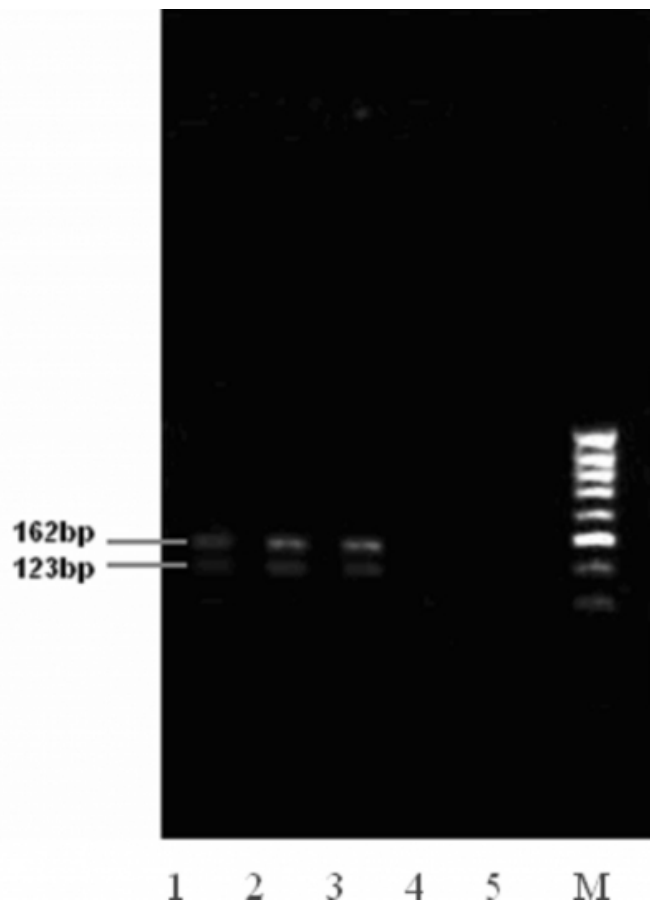


Figure 6

Figure 2: Acid fast staining (1000x) on bronchial FFPE.

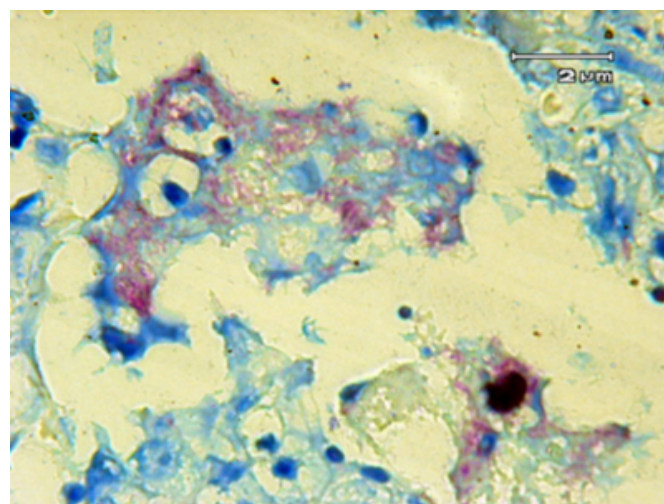
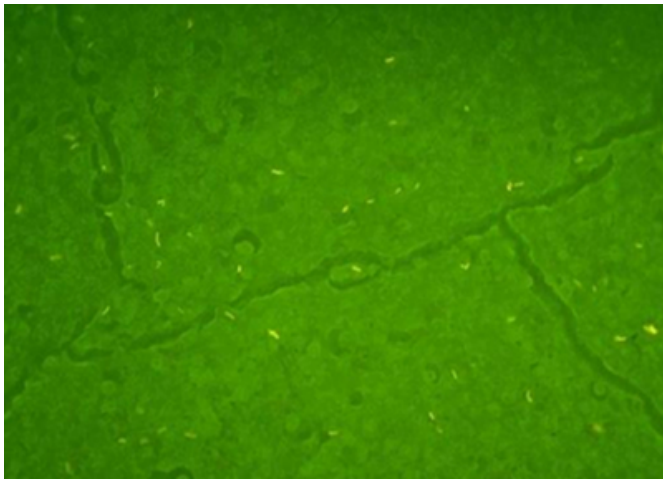


Figure 7

Figure 3: Rhodamine- Auramine staining (450X)



DISCUSSION

Rapid diagnosis of MTC and NTMC has an impact on the management of patients. The detection of MTC in clinical samples leads to initiation of correct treatment thereby avoiding or diminishing severe complications.

Several amplification methods are available now and are useful for patients in whom diagnosis depends on tissue examination rather than detection of *M. tuberculosis* in body secretion. (1,3,12). This method renders a feasible, rapid and easy tool to perform retrospective diagnosis of *M. tuberculosis* infection. Which would be particularly useful when there is a lack of growth on culture or when fresh material has not been collected for culture. Several factors affect the result of PCR in FFPE samples such as target DNA size, DNA concentration, and target fragment repetitiveness within the mycobacterial genome (1). Many reports have confirmed that PCR amplification in formalin-fixed tissues detects TB DNA when only a few genomes are present. (3,7,14)

We designed a Multiplex PCR with two DNA fragment targets:

123bp DNA fragment from IS 6110 which is present in organisms of the *M. tuberculosis* complex group (MTB, *Mycobacterium bovis*, *Mycobacterium bovis* bacille Calmette-Guérin, *Mycobacterium africanum*, *Mycobacterium microti*) and is absent in other species of mycobacteria. The IS6110 sequence is a repetitive mobile genetic element and is a good target for diagnosis because of its specificity and its presence in high copy numbers in most strains of the

MTB complex. (5,6,15)

162bp DNA encoding Ag 85 complex which is present in all groups of mycobacteria.

The sensitivity of our Duplex PCR was % 65, which is similar to or lower than that of other reports. Most of the authors reported the sensitivity of 60 to 90 percent and the specificity of 95 to 100 percent for FFPE (3,4,5,7,9,15,17). The specificity of our Duplex PCR was %100. Our study shows that a properly designed PCR assay can successfully be used to detect *M. tuberculosis* in formalin fixed paraffin embedded tissues. It is evident that further investigation need to be conducted in order to ameliorate and possibly standardize a protocol of DNA amplification from archived material. We believe that TB PCR is a suitable method for the diagnosis of tuberculosis in routinely processed, formalin fixed and paraffin embedded histologic specimens, although application of the PCR method to formalin fixed, paraffin embedded tissue has shown several limitations, including DNA structure change due to prolonged formalin fixation. (17). Although PCR reduce the delay in diagnosis, culture remains the gold standard for identification of mycobacteria in tissues. Culture also allows for the testing of antibiotic sensitivity of any isolated species, in this way determining appropriate treatment. (3,16,18)

In this study, we didn't use mycobacterial culture of tissue specimens as a reference for the TB PCR; instead, we used the pathologic feature of TB granuloma as a comparative reference for TB PCR. The ability of detection of nontuberculous mycobacteria was the advantage of this Duplex PCR although NMTC didn't detect.

Acid fast and R-A staining are rapid and inexpensive methods for diagnosis tuberculosis but in this study these methods sensitivity was not significant (Table 4) which is similar to other reports. (3,6,9)

Some researchers have suspected that the organic tissue samples might affect the stainability of mycobacteria by Acid fast staining. (3,14)

This hypothesis seems reasonable because the molecular target of the acid fast staining dyes (fuchsin, auramine) is the mycolate in the bacterial cell wall. Mycolate is soluble in organic agents (3). However, this result should not discourage pathologist from using Acid fast and A-R staining to evaluate mycobacterial lesions.

CONCLUSION

Multiplex PCR was a sensitive, specific and rapid method for detection of Mycobacterium tuberculosis in paraffin embedded samples. Acid fast and R-A staining are rapid and inexpensive methods. These methods are specific but their sensitivity was not significant in this study.

ACKNOWLEDGEMENT

This paper was supplied financially by a research grant: 84026 from the vice Chancellor for research of Mashhad University of medical sciences Mashhad- Iran.

CORRESPONDENCE TO

Dr Abbasali Omid, MD, Department of Pathology, Ghaem Hospital, Ahmad abad Blvd., Mashhad, Iran., Tel. 00985118012399, E-mail: aomidia@yahoo.com

References

1. Chakravorty S, Sen MK, Tyagi JS. Diagnosis of Extrapulmonary tuberculosis by smear, culture, and PCR using universal sample processing technology. *J. Clin. Microbiol.*, 2005 Sep; 43 (9): 4357- 4362.
2. Li Z, W. Qin W. Yue Q. Meng Q. Lin Q. Study on detection of the mycobacteria DNA in formalin-fixed, paraffin-embedded tissue samples by triplex polymerase chain reaction. *Wei Sheng Wu Xue Bao.* 2002 Feb; 42(1): 69-75.
3. H. Fukunaga, T. Murakami, T. Gondo, K. sugi T. Ishihara. Sensitivity of Acid- fast staining for mycobacterium tuberculosis in formalin- fixed tissues. *American Journal of Respiratory and critical care medicine.* 2002; 166. 994-997.
4. Li JY, lo ST, Ng CS. Molecular detection of mycobacterium tuberculosis in tissues showing granulomatous inflammation without demonstrable acid fast bacilli. *Diagn Mol pathol* 2000; 9: 67-74.
5. Salian NV, Rish JA, Eisenach KD, Cave MD, Bates JH. Polymerase chain reaction to detect Mycobacterium tuberculosis in histologic specimens. *Am J Respir Crit Care Med.* 1998; 158(4): 1150-5.
6. Selva E, Hofman V, Berto F, Musso S, Castillo L, The value of polymerase chain reaction detection of Mycobacterium tuberculosis in granulomas isolated by laser capture microdissection. *Pathology.* 2004 Feb; 36 (1): 77-81.
7. Mustafa AS, Abal AT, chugh. TD, Detection of Mycobacterium tuberculosis complex and non tuberculous Mycobacteria by Multiplex polymerase chain reaction. *Eastern Mediterranean Health Journal.* 1999; 5 (1): 61-70.
8. Wiker HG et al. Evidence for three separate genes encoding the proteins of the Mycobacterium tuberculosis complex, *Infection and Immunity.* 1990 Jan; 58(1): 272-4.
9. Sharma S, Mallick GP, Verma R, Ray SK. Polymerase chain reaction Amplification of IS6110 Sequence to detect Mycobacterium tuberculosis complex from formalin - fixed paraffin- embedded Tissues of Deer. *Vet Res Commun.* 2007 Jan; 31 (1): 17-21.
10. Bass Jr JB et al. Diagnostic standard and classification of tuberculosis and other Mycobacterial disease. *American review of respiratory disease,* 1999 123: 343-58.
11. Van sooling D et al. Insertion element IS1081-associated restriction fragment length polymorphism in Mycobacterium tuberculosis complex species: a reliable tool for recognizing Mycobacterium bovis BCG. *Journal of Clinical Microbiology,* 1992 Jul, 30(7): 1772-7.
12. Jambhekar NA, Kulkarni SP, Madur BP. AgarwalS, Rajan MG. Application of the polymerase chain reaction on formalin-fixed, paraffin embedded tissue in the recognition of tuberculous osteomyelitis. *J Bone Joint surg Br.* 2006 Aug; 88 (8): 1097-101.
13. Hillemann D, Galle j, Vollmer E, Richter E. Real-time PCR assay for improved detection of mycobacterium tuberculosis complex in paraffin embedded tissues. *Int J tuberc lung Dis.* 2006 Mar; 10(3): 340-2.
14. Fite E, Fenandez Figueras MT, Prats R, Vaquero M, Morera J. High prevalence of Mycobacterium tuberculosis DNA in biopsies from sarcoidosis patients from Catalonia, Spain. *Respiration.* 2006, 73 (1): 14-5.
15. Ardeleanu C, Andrei F, ceausa M, Ene D, Mihai M, Butur G. et al. Cellular immune response in atypical tuberculosis diagnosed by PCR in paraffin embedded material. *Rom J Morphol EmbryoL.* 1999-2004; 45: 63-72.
16. Schultz S, Carbras AD, Kremer M, Weirich G, M Michke T, et al. Species identification of Mycobacteria in paraffin embedded tissues: frequent detection of nontuberculous Mycobacteria. *Mod Pathol.* 2005 Feb; 18(2): 274-82.
17. Zink AR, Nerlich AG. Molecular strain identification of the Mycobacterium tuberculosis complex in archival tissue samples. *J Clin pathol.* 2004 Nov; 57 (11): 1185-92.
18. Cataloluk O, Cakmak EA, Buyukberber N, Barlas O. Formalin Fixing and paraffin embedding may lead to extra band development in PCR. *New Microbiol.* 2003 Apr; 26(2): 193-8

Author Information

Javad Ghenaat

Department of Microbiology, Ghaem Hospital Mashhad University of Medical Sciences

Abbasali Omid

Department of Pathology, Ghaem Hospital Mashhad University of Medical Sciences

Kiarash Ghazvini

Department of Microbiology, Ghaem Hospital Mashhad University of Medical Sciences

Hossein Ayatollahi

Department of Biochemistry, Ghaem Hospital Mashhad University of Medical Sciences

Amir Hossein Jafarian

Department of Pathology, Ghaem Hospital Mashhad University of Medical Sciences

Minoo Erfanian

Department of Pathology, Ghaem Hospital Mashhad University of Medical Sciences

Mohammad Taghi Shakeri

Ghaem Hospital Mashhad University of Medical Sciences

Mahmoud Bagheri

Department of Microbiology, Ghaem Hospital Mashhad University of Medical Sciences

Hooman Tavassolian

Department of Pathology, Ghaem Hospital Mashhad University of Medical Sciences