



Prevalence of proline racemase/ hydroxyproline epimerase gene in human *brucella* isolates in Iran

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Abstract

Background: Human brucellosis is a zoonotic disease caused by *Brucella melitensis*, *Brucella abortus*, and *Brucella suis*. *Brucella* causes a chronic disease, which subverts the immune defense system of their hosts. In this study, the prevalence of an important *Brucella* virulence determinant, PrpA, which can modulate immune response, was determined in human isolates.

Methods: Polymerase chain reaction (PCR) assay was standardized and applied to 37 isolates obtained from patient's specimens. Primers for *prpA* gene were designed and evaluated using bioinformatic tools. DNA sequencing was performed for further verification.

Results: In the 37 *Brucella* isolates (31 *Brucella melitensis* and 6 *Brucella abortus*), 32 (86.4%) carried *prpA* gene.

Conclusion: Presence of *prpA* gene in most isolates indicates the high prevalence of this gene among Iranian isolates and emphasizes its role in pathogenicity of this organism.

Keywords: *Brucella* species, Brucellosis, Proline Racemase, PrpA

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Introduction

Brucella, a Gram negative coccobacillus, is responsible for brucellosis in domestic and wild animals and is transmittable to human hosts. Although humans are not the main sources of infection, the disease causes socio-economic problems in many countries (1). Broad spectrum of mammals is at risk of becoming infected with *Brucella*. Humans are mainly infected by *Brucella melitensis*, *Brucella abortus*, and *Brucella suis* (2-3). Human brucellosis is transmitted through several routes such as ingestion of contaminated dairy products, inhalation, and direct contact with infected animal tissues; however, person to person transmission is extremely rare (4-5). The disease is febrile and debilitating for human hosts, with particular problems and constitutional symptoms (6). Additionally, brucellosis is a chronic and persistent infection with a capacity of becoming granulomatous (7).

Pathogenicity in *Brucella* and other intracellular organisms such as *Leishmania* spp., *Trypanosomes* and *Salmonella typhi* depends on survival and replication of the organism inside the host cell. These pathogens develop mul-

tiples approaches to subvert the host immune responses. The ability to hide and survive in host cells leads to establishment of a chronic infection (8-9). Accordingly, *Brucella* utilizes numerous factors such as type IV secretion system (VirB), cyclic β 1, 2-glucans, and LPS to manipulate the host's immune system. Identification of new putative factors has opened many doors for better understanding of pathogenicity (10).

Brucella PrpA (Proline Racemase Protein A), homologous to a proline racemase with mitogenic activity in the human protozoan parasite *Trypanosoma cruzi*, is a T-independent B lymphocyte mitogen and a potent IL-10 inducer required for the establishment of chronicity and the early immune suppression observed in mice after infection (10). PrpA uses NMM-IIA (nonmuscular myosin IIA) for attachment to macrophages to activate lymphoproliferation (11). Although PrpA has been described as immunomodulatory molecule in several pathogens (12-14), there had been no information on the prevalence of PrpA in *Brucella* species in Iran. In the present study, a

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↑What is "already known" in this topic:

PrpA as an immunomodulatory molecule activates IL-10 and stimulates B cell replication. Organism such as *Brucella* requires PrpA to establish chronic infections.

→What this article adds:

High prevalence of *prpA* gene in human *Brucella* isolates may increase the virulence capacity among Iranian isolates of *B. melitensis* and *B. abortus*.

Table 1. PCR primer sequence used for amplification of the Brucella prpA gene.

Target gene	Primer designation	Oligonucleotide sequence (5'-3')	PCR product (bp)
PrpA	PrpA-F	AACCTCAATGGATCGACC	672
	PrpA-R	ACGGTCGATAGCCTTGTC	

PCR assay was developed to detect *prpA* gene that was applied to 37 *B. melitensis* and *B. abortus* isolates obtained from patients in cities of Tehran, Arak and Hamadan in Iran.

Methods

Bacterial strains

From a total of 37 isolates, 31 *B. melitensis* and 6 *B. abortus* were identified based on bacteriological tests such as colony morphology, Gram staining, oxidase, catalase, CO₂ growth, H₂S production, and dye tolerance such as basic fushin and thionin.

DNA preparation

A loopful of colonies of each isolate on *Brucella* agar plates was picked and suspended in 200 µL of distilled water. After vortexing, the suspension was boiled for 5 minutes, and 50 µL of the supernatant was collected after spinning at 14 000 rpm for 10 minutes. The DNA concentration of the boiled extracts was determined with a spectrophotometer.

PCR assay

PCR amplifications were performed in a final volume of

25 µL in PCR tubes. The reaction mixtures consisted of 2 µL of the DNA template, 1 µL of each primer, 8 µL of mastermix (Taq DNA polymerase Mastermix Mix Red, MgCl₂, Amplicon), and the total volume was adjusted to 25 µL using distilled deionized water. PCR program for amplification of *prpA* consisted of initial denaturation at 94°C for 4 minutes, 30 cycles of application with denaturation at 94°C for 1 minute, annealing at 58°C for 1 minute, extension at 72°C for 1 minute, and final extension at 72°C for 10 minutes. Electrophoresis of PCR products was performed on 1.5 % agarose gels using 100-bp DNA ladder as molecular size marker. Gels were visualized under UV and documented using Uvitec System DOC-008.XD (EEC).

Primer designation and DNA sequencing

The nucleotide sequence of *Brucella prpA* gene was obtained from *B. melitensis* 16M chromosome II complete sequence (AE008918.1) in NCBI GenBank database. Specific primer set was designed based on pairwise and multiple sequence alignment for the corresponding gene using CLC Sequence Viewer Version 6.8.2. The primer sequences and their amplicon size are demonstrated in Table 1.

Table 2. Demographic characteristics of human Brucella isolates.

NUMBER	GENDER	SPECIMEN TYPE	BRUCELLA SPECIES	STRAIN	PROVINCE/CITY
1	Female	CSF	B. melitensis	1-A	Arak
2	Female	CSF	B. melitensis	2-A	Arak
3	Male	Blood	B. melitensis	3-A	Arak
4	Male	Blood	B. melitensis	4-A	Arak
5	Female	Blood	B. abortus	5-A	Arak
6	Male	CSF	B. melitensis	12-A	Arak
7	Male	Blood	B. abortus	16-A	Arak
8	Male	Blood	B. melitensis	19-A	Arak
9	Male	Blood	B. melitensis	20-A	Arak
10	Female	Blood	B. melitensis	18-H	Hamadan
11	Male	Blood	B. melitensis	22-H	Hamadan
12	Female	Blood	B. melitensis	33-H	Hamadan
13	Male	Blood	B. melitensis	34-H	Hamadan
14	Male	Blood	B. melitensis	35-H	Hamadan
15	Female	Blood	B. melitensis	39-H	Hamadan
16	Male	Blood	B. melitensis	40-H	Hamadan
17	Male	Blood	B. abortus	46-H	Hamadan
18	Male	Blood	B. melitensis	48-H	Hamadan
19	Male	Blood	B. melitensis	54-H	Hamadan
20	Male	Blood	B. melitensis	1-T	Tehran
21	Female	Blood	B. melitensis	2-T	Tehran
22	Female	Blood	B. abortus	3-T	Tehran
23	Female	Blood	B. melitensis	5-T	Tehran
24	Male	CSF	B. abortus	11-T	Tehran
25	Female	Blood	B. abortus	18-T	Tehran
26	Male	Blood	B. melitensis	19-T	Tehran
27	Male	Blood	B. melitensis	21-T	Tehran
28	Female	Blood	B. melitensis	22-T	Tehran
29	Male	CSF	B. melitensis	24-T	Tehran
30	Male	Blood	B. melitensis	27-T	Tehran
31	Male	Blood	B. melitensis	29-T	Tehran
32	Male	Blood	B. melitensis	30-T	Tehran
33	Female	Blood	B. melitensis	31-T	Tehran
34	Female	CSF	B. melitensis	32-T	Tehran
35	Female	CSF	B. melitensis	33-T	Tehran
36	Male	CSF	B. melitensis	385-T	Tehran
37	Male	Blood	B. melitensis	14508-T	Tehran

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Table 3. Distribution *prpA* genes among 37 human *Brucella* isolates.

Virulence gene	Human isolates (n=37)	
	<i>B. melitensis</i> (n=31)	<i>B. abortus</i> (n=6)
<i>prpA</i>	31 (100)	1 (16.7)

The amplified fragment of *prpA* gene was purified using Silica Bead DNA Gel Extraction Kit (Thermo Scientific, USA). Sequencing was performed on both strands using an automated sequencer system (ABI 3730xl DNA Analyzer). DNA sequences were edited by Chromas Lite Version 2.5.1 (Technelysium Pty Ltd, Australia) and BioEdit Version 7.2.5 (Hall, 1999).

Results

From a total of 37 isolates, 31(83.7%) *B. melitensis* and 6 (16.3) *B. abortus* were identified from 29 blood and 8 CSF human samples. Of the patients, 23 (62%) were male and 14 (38%) were female. Detailed information on specimen type, *Brucella* species type, and areas of sample collection are presented in Table 2. As expected, *prpA* gene assay produced an amplicon of 672 bp (Fig. 1).

In the current study, all *B. melitensis* isolates had *prpA* gene; however, just one of the six *B. abortus* isolates was positive for this gene (Table 3). Analysis of the sequenced gene with Chromas software and blast in the NCBI (National Center for Biotechnology Information) site showed the same DNA sequences; therefore, all the PCR assay results were confirmed.

Discussion

Brucella has an amazing ability to adapt to hosts' cellular atmosphere and evade immune responses. Other organisms which cause chronic diseases such as *Mycobacterium tuberculosis*, *Salmonella* spp, and *Trypanosoma cruzi* use

the same mechanism to reach their replication niche (15). Although little is known about the molecular mechanisms of *Brucella* virulence factors, numerous putative factors have been identified (16).

The present study aimed at identifying *B. melitensis* and *B. abortus* strains, which were carriers of *prpA* gene. Our results confirmed the presence of *prpA* gene in 32 (86.4%) *B. melitensis* and *B. abortus* isolates collected from human patient specimens. Interestingly, 5 out of 6 *B. abortus* isolates lacked this gene, which is not completely consistent with the result of Spera et al. (10). Our findings revealed the presence of *prpA* gene in human isolates of *Brucella* (100% *B. melitensis*, and 16.6% *B. abortus*) and not in animal isolates, which may be responsible for variations in results. It can be concluded that the present gene is more frequent in *B. melitensis* strains compared with *B. abortus* strains in Iran; however, there is no warrant for expression of the gene.

Proline racemase protein, a homodimeric enzyme, was initially identified in *Clostridium sticklandii* protobacterium; however, a eukaryotic proline racemase was first isolated from *Trypanosoma cruzi*(TcPRAC), the causative agent of Chagas disease (17). According to Goytia et al., Proline racemase function is similar to hydroxy proline epimerase activity as a lymphocyte mitogen (18). This enzyme is capable of converting L and D-proline enantiomers reversibly (19); D-amino acids are often found in eukaryotes and bacterial cell walls (20). Proline racemase antibodies and inhibitor, and pyrrole-2-carboxylic acid (PYC) exert influence on the infection of *T. cruzi* in vitro. PYC can also interfere in intracellular *T. cruzi* differentiation (19). PrpA in *Brucella* is a molecular virulence factor, which can put the host's immune system in an anergic state (10).

Conclusion

The present study demonstrated a very high level of *prpA* gene presence in human *Brucella* isolates. The design of a PCR test to assess the presence of aforementioned gene was a first attempt to understand the mechanism of virulence, especially in Iranian isolates of *Brucella melitensis* and *Brucella abortus*. For further understanding of *prpA* genetic epidemiology, similar studies on animal isolates may be required.

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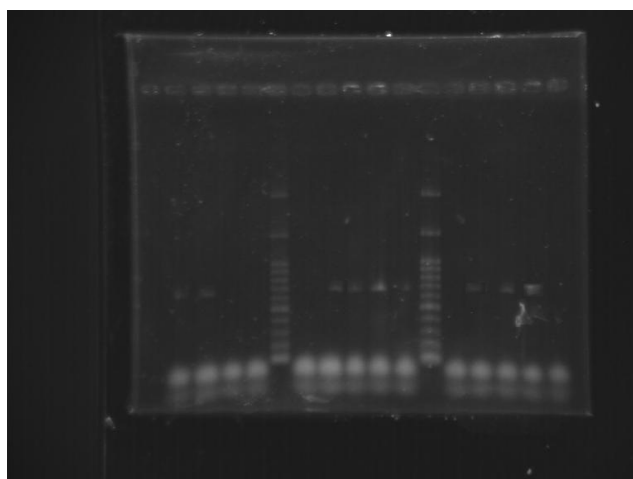


Fig. 1. Representative PCR products of *Brucella prpA* gene from human strains of *B. melitensis* and *B. abortus*. Lanes M, DNA Ladder Mix; Lanes 2,3,7,8,9,10,12,13 are *Brucella melitensis* strains positive for *prpA*, Lane 14 *Brucella abortus* strain positive for *prpA*, Lanes 4,5,6,11,15 are *Brucella abortus* strains negative for *prpA*.

Conflict of Interests

The authors declare that they have no competing interests.

References

1. Pappas G. The changing Brucella ecology: novel reservoirs, new threats. *Int J Antimicrob Agents*.2010;36:1:8-11.
2. Mantur BG,Amarnath SK,Shinde RS. Review of clinical and laboratory features of human brucellosis. *Indian J Med Microbiol*.2007;25:188-202.
3. Godfroid J,CloECKaert A,Liautard JP,Kohler S,Fretin D,Walravens K, et al. From the discovery of the Malta fever's agent to the discovery of a marine mammal reservoir, brucellosis has continuously been a re-emerging zoonosis. *Vet Res*.2005;36:313-326.
4. Mesner O,Riesenberg K,Biliar N,Borstein E,Bouhnik L,Peled N, et al. The many faces of human-to-human transmission of brucellosis: congenital infection and outbreak of nosocomial disease related to an unrecognized clinical case. *Clin Infect Dis*.2007;45:e135-40.
5. Baldi PC,Giambartolomei GH. Pathogenesis and pathobiology of zoonotic brucellosis in humans. *Rev Sci Tech*.2013;32:117-25.
6. Franco MP,Mulder M,Gilman RH,Smits HL. Human brucellosis. *Lancet Infect Dis*.2007;7:775-786.
7. HasanjaniRoushan MR,Mohrez M,SmailnejadGangi SM,SoleimaniAmiri MJ,Hajiahmadi M. Epidemiological features and clinical manifestations in 469 adult patients with brucellosis in Babol, Northern Iran. *Epidemiol Infect*.2004;132:1109-1114.
8. Kaufmann SH. Intracellular pathogens: living in an extreme environment. *Immunol Rev*.2011;240:5-10.
9. Spera JM,Herrmann CK,Roset MS,Comerci DJ,Ugalde JE. A Brucella virulence factor targets macrophages to trigger B-cell proliferation. *J Biol Chem*.2013;288:20208-16.
10. Spera JM, Ugalde JE,Mucci J, Comerci DJ, Ugalde RA.A B lymphocyte mitogen is a Brucellaabortus virulence factor required for persistent infection. *ProcNatlAcadSci USA*. 2006;103:16514-16519.
11. Coutinho L,Ferreira MA,Cosson A,Batista MM,Batista Dda G,Minoprio P. Inhibition of Trypanosomacruziprolineracemase affects host-parasite interactions and the outcome of in vitro infection. *Mem-Inst Oswaldo Cruz*.2009;104:1055-62.
12. Wang Y,Chen Z,Qiu Y,Ke Y,Xu J,Yuan X. Identification of Brucellaabortus virulence proteins that modulate the host immune response. *Bioengineered*.2012;3:303-5.
13. Byndloss MX,Tsolis RM. *Brucella* spp. virulence factors and immunity. *Annu Rev AnimBiosci*. 2015;4:111-127.
14. Atluri VL,Xavier MN,de Jong MF,den Hartigh AB,Tsolis RM. Interactions of the human pathogenic Brucella species with their hosts. *Annu Rev Microbiol*.2011;65:523-41.
15. Delrue RM, Martinez-Lorenzo M, Lestrade P, Danese I, Beilar V, Mertens P, et al. Identification of Brucella spp. genes involved in intracellular trafficking. *Cell Microbiol*. 2001;3:487-497.
16. de Jong MF,Tsolis RM. Brucellosis and type IV secretion. *Future Microbiol*.2012 Jan;7:47-58.
17. Coatnoan N,Berneman A,Chamond N,Minoprio P. Prolineracemas: insights into Trypanosomacruzi peptides containing D-proline. *MemInst Oswaldo Cruz*.2009;104:1:295-300.
18. Goytia M,Chamond N,Cosson A,Coatnoan N,Hermant D,Berneman, et al. Molecular and Structural Discrimination of ProlineRacemase and Hydroxyproline-2-Epimerase from Nosocomial and Bacterial Pathogens. *PLoS ONE*. 2007;2:e885.
19. Chamond N, Grégoire C, Coatnoan N, Rougeot C, Freitas-Junior LH,da Silveira JF,et al. Biochemical characterization of prolineracemas from the human protozoan parasite Trypanosomacruzi and definition of putative protein signatures. *J Biol Chem*.2003 2;278:15484-15494.
20. Buschiazzo A,Goytia M, Schaeffer F, Degrave W, Shepard, W, Grégoire C, et al. Crystal structure, catalytic mechanism, and mitogenic properties of Trypanosomacruziprolineracemase. *Proc Natl Acad Sci USA*. 2006;103:1705-1710.