Genotyping of *Cryptosporidium* spp. in clinical samples: PCR-RFLP analysis of the TRAP-C2 gene

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**ABSTRACT**

**Aim:** The aim of the present study was to determine the species and genotypes of *Cryptosporidium* spp. among children with diarrhea by PCR-RFLP using the TRAP-C2 gene.

**Background:** *Cryptosporidium* is a globally distributed protozoan parasite and one of the most common causes of infection and diarrhea in humans.

**Patients and methods:** Four hundred and sixty-nine stool samples were collected from children less than 12 years with diarrhea who had been referred to Pediatrics Medical Centers in Gazvin provinces. The presence of *Cryptosporidium* oocysts was determined by Ziehl-Neelsen acid fast staining, then, genomic DNA was extracted from positive samples and nested PCR-RFLP was performed to amplify the TRAP-C2 gene.

**Results:** The overall prevalence of *Cryptosporidium* infection in children was 2.5%. Results of nested PCR amplification showed that of 12 positive children samples, 10 (83.3%) were belonged to *C. parvum*, followed by *C. hominis* in 1 (8.3%) and mixed infection in 1 isolate (8.3%).

**Conclusion:** This study showed that *Cryptosporidium parvum* (the zoonotic genotypes) is more prevalent than other *Cryptosporidium* species in children from this area. This suggests that zoonotic transmission is the main mode of transmission of *Cryptosporidium* infection in Iran.

**Keywords:** *Cryptosporidium*, Genotypes, TRAP-C2 gene.

(Gastroenterology and Hepatology From Bed to Bench 2011; 4(1): 29-33).

**Introduction**

*Cryptosporidium* is a protozoa infection which is a cause of diarrhea in children and immunocompromised patients throughout the world. Currently 18 *Cryptosporidium* species have been recognized. *Cryptosporidium parvum* and *C. hominis* are the species predominantly found in humans. Other species found in a variety of hosts includes *C. meleagridis*, *C. felis*, *C. canis*, *C. suis*, *C. muris*, *C. andersoni*, *C. baileyi* (1).

In recent years, researchers have developed PCR-based techniques for detection and identification of *Cryptosporidium* spp. These techniques are based on the polymorphic nature of the *Cryptosporidium* oocyst wall protein (*COWP*), the dihydrofolate reductase (*DHFR*), thrombospondin related adhesive protein 1 (*TRAP-C1*), thrombospondin-related adhesive protein 2 (*TRAP-C2*), internally transcribed spacer 1 (*ITS1*), polythreonine repeat (*Poly-T*), small-subunit (*SSU*) rRNA genes and undefined genomic sequences among strains that infect humans and most animals at (2-6). Previous studies of cryptosporidiosis in Iran have been performed using microscopy (7-12) and
recently studies of Cryptosporidium molecular characterization have been conducted (13-14).

In this study we identified the genotypes of the Cryptosporidium isolates from clinical samples using polymerase chain reaction (PCR) amplification and restriction fragment length polymorphism (RFLP) analyses of the TRAP-C2 gene (Thrombospondin-Related Adhesive Protein of Cryptosporidium-2).

**Materials and Methods**

**Sampling**
A total of 469 fecal samples were collected from children with diarrhea who had been referred to Pediatric Medical Centers in Ghazvin, Iran. Cryptosporidium oocysts were identified in samples after concentration by formalin–ethyl–acetate sedimentation and staining with a modified Ziehl-Neelsen technique. The positive Cryptosporidium spp. isolates were preserved in 2.5% potassium dichromate and kept at 4°C until used for DNA extraction.

**DNA extraction**
Approximately 300 µl of fecal suspension was washed three times with distilled water to remove trace of dichromate and then genomic DNA was extracted using the DNAzol kit according to the manufacturer’s instructions (Invitrogen, life technologies, Cat. No 10503-027, USA) with the addition of three freeze-thaw cycles (10 minutes) after resuspending the DNA samples in lysis (to rupture the Cryptosporidium oocysts). The oocysts were frozen in liquid nitrogen. Thawing was carried out at 90°C in water bath.

**TRAP-C2 gene amplification**
Nested PCR was used to amplify a fragment (266-366 bp) of the TRAP-C2 gene using two sets of oligonucleotideprimers: CATATTCCTGTCCTTGAGTTGT and TGGACAACCCAAATGCAGAC for primary PCR and GGTAATGGTCACGA and CCAAGTTTCAGGCTTA for secondary PCR, as described previously (2, 5). PCR products were visualized on 1% agarose gel after ethidium bromide staining.

**RFLP analysis**
For restriction fragment length polymorphism (RFLP) analysis of secondary PCR products, we used restriction enzymes BstEII, HaeIII for TRAP-C2 gene. The restriction digestion products were visualized by electrophoresis on 2% agarose gel after ethidium bromide staining.

**Results**
In this study Cryptosporidium isolated from children with diarrhea in Gazvin province of Iran were characterized by PCR-RFLP. From all isolates thought to possibly contain Cryptosporidium, oocysts were detected and then stained by modified Ziehl-Neelsen method.

From the 469 samples, a total of 12 Cryptosporidium isolates were characterized. The TRAP-C2 gene fragment of all isolates was successfully amplified from 12 positive samples. RFLP analysis of the nested PCR products by using two enzymes (BstEII, HaeIII) showed that 10 out of 12 isolates (83.3%) were C. parvum, 1 (8.3%) C. hominis and one isolate (8.3%) showed mix infection pattern of C. parvum and C. hominis (Fig1 and Fig 2).

![Figure 1](image) Molecular diagnosis of Cryptosporidium spp. by a nested PCR based on TRAP-C2 gene. Lane 1: 100 bp DNA marker, Lane 2-9: PCR product, Lane10: negative control
with a rate of 83.4%, is the predominant species in children. Our study is therefore in agreement with a previous similar study performed in Iran (1); and the results are comparable to other studies performed in countries such as the United Kingdom, Kuwait, France, Switzerland and the Netherlands (20-24).

The predominance of *C. parvum* in humans may be due to high prevalence of bovine cryptosporidiosis in this area. By comparison *C. hominis* is the predominant species found in similar studies in other nations such as Brazil, Kenya, Malawi, the United States, Thailand, Japan and South Africa (25-28). We can conclude that the *C. parvum* is the predominant cause of *cryptosporidium* infection in Iran.

Furthermore the use of *TRAP-C2* primers could be an alternative diagnostic method to identify human infection with *Cryptosporidium*. Information generated from this diagnostic approach would be useful, not only in diagnosis and identification of the sources of contamination, but also in controlling the disease.

Further molecular characterization on human and animals is needed, to increase our knowledge about *Cryptosporidium* and its transmission.

**Acknowledgements**

We acknowledge the very helpful assistance of Prof. Lihua Xiao from Division of Parasitic Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Public Health Services, U.S.

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