Original article

Parasite infections among people living in a high altitude area of La Paz, Bolivia

Kikuo Ikegami[1], Yasuo Tsuchiya[1], Yoshito Nishi[2], Silvia Heredia Gonzales[2], Tomizo Oyama[1], Toshikazu Ikoma[1], Takao Asai[1], Hiroho Sekikawa[3]

[1] Department of Clinical Engineering and Medical Technology, Niigata University of Health and Welfare, Niigata, Japan
[2] Hospital San Francisco de Asis, La Paz, Bolivia
[3] School of Medicine, Niigata University, Niigata, Japan

Abstract

Determining the accurate rate of human parasite infections is of great importance in developing a strategy to prevent the infections. We aimed to demonstrate the parasite infection rates in people living in a high altitude area of La Paz, Bolivia. Feces were collected from 301 people, but 274 (137 males and 137 females) were considered as our study subjects because in 27 the age or sex was unknown. Feces were examined by the formalin-ether medical sedimentation method to find helminth eggs and protozoan cysts. The rates of helminth, protozoal and mixed infection with both of them were 1.8% (5), 39.1% (107) and 2.9% (8) cases among 274 examinee, respectively. The rates of the 4 helminth detected were as follows: 0.7% (2), *Ascaris lumbricoides*; 2.2% (6) *Trichuris trichiura*; 2.2% (6) *Hymenolepis nana*; 0.4% (1) *Strongyloides stercoralis*; and those of 5 protozoan parasites were 15.0% (41) *Giardia lamblia*; 3.3% (9) *Entamoeba histolytica*: 22.6% (62) *Entamoeba coli*; 4.7% (13) *Endlimax nana*; 1.1% (3) *Iodamoeba buetschlii*, respectively. The Infection rates were 42.3% (58/137) in males and 45.3% (62/137) in females. No significant differences were recognized in the detection rates between the males and the females. However, the infection rate of 7.7% (2/26) of *E. coli* in the females at age of 15 years and elder was significantly lower than that of 29.7% (33/111) in those younger less than 15 years old. Protozoal infection accounted for a large portion of the parasite infections among the subjects. Preventive measures against parasite infections in this area should largely focus on protozoal infections.

Introduction

Intestinal parasites have been found to be among the most common infections in the poorest people living in the Latin American and Caribbean regions [1,2]. In particular, intestinal parasite infections among children lead to severe diarrhea and nutritional deficiency. In children with a poor state of general health, diarrhea due to parasite infection is frequent and severe [3-5]. The World Health Organization has described parasitic disease as "the neglected tropical disease" and has focused on a comprehensive approach to parasitic disease that encompasses not only medical treatment but also seeks to alleviate poverty and improve education [6-9].

Corresponding author: Kikuo Ikegami

Department of Clinical Engineering and Medical Technology, Niigata University of Health and Welfare, 1398 Shimami-cho, Kita-ku, Niigata 950-3195, Japan.

TEL/FAX: +81-25-257-4409, E-mail: ikegami@nuhw.ac.jp

Bolivia has one of the highest rates of intestinal parasite infection [10]. Tanner et al. [11] found that the parasite infection rates in people living in lowland Bolivia were as follows: 76% *Ancylostoma* or *Necator*, 7% *Ascaris lumbricoides*, and 5% *Trichuris trichiur*, with a 77% overall infection rate. On the other hand, Flores et al. [12] reported that the rates of parasite infection among school children living in La Paz (the capital city of Bolivia) were as follows: 11.6% *A. lumbricoides*, 8.4% *T. trichiur* and 2.1% mixed infection with both of them. However, among the general community those were: 14.9%, 13.9% and 5.0%, respectively.

The infant mortality rate is very high in Bolivia because of the severe living environment. According to World Health Statistics 2013, about 39 of 1,000 babies died before reaching 1 year of age in Bolivia in 2011 [13]. In addition, about 51of 1,000 babies died before reaching 5 years of age in 2011 [14]. Those high mortality rates may be explained by intestinal parasite infections or malnutrition [15]. However, no group feces examination or anthelmintic prescription has been conducted in this area because parasite infections are not consisted to associate directly with death.

This study was conducted as a preliminary investigation for contributing to the measures for the prevention of parasite infection in La Paz. Based on the obtained results, we aim to assist health professionals in taking measures to against parasite infection.

Subjects and methods
Study area

La Paz has a population of 1,900,000 people and is the capital of Bolivia, and is on a plateau 3,000-4,000 meters above sea level. Our research area, Asis, is located at a height of 3,800 meters above sea level, and the annual mean temperature is 7-10°C. This study was conducted with the cooperation of the San Francisco Hospital in Asis between February 13 and 19, 2012.

Subjects

Although feces were collected from 301 people, 274 (sex; 137 males and 137 females, mean age; 8.2 and 12.2, range; 1-54 and 1-71 years old, respectively) were included as our study subjects because the age or sex was unknown in 27 cases. All 274 subjects were assigned to the following two age groups: less than 15 years old, or 15 years and elder.

Feces examination

The feces examination was carried out using the formalin-ether sedimentation method [16]. Iodine solution was used for the proper observation of protozoans.

Definition of parasitosis, Handling after the examination

When helminth eggs or protozoan cysts were detected in feces, we considered the subject to have a parasite infection [17]. The subjects were informed of all of the results, and the administration of vermicide to infected subjects was carried out by a medical doctor from the cooperating hospital.

This study was approved by ethics committee in Niigata University of Health and Welfare (17298-120125).

Statistical analysis

All statistical procedures were performed using statistical analysis software (IBM SPSS Statistics, ver. 17). To compare the infection rates between males and females, or by age group, we used the chi-square test or Fisher's exact probability test. Differences were considered significant when the p-value was less than 0.05.

Result

Table1 shows the infection rates of helminth and protozoa by gender. The number of parasite-infected subjects was 120 (43.8%) out of 274. The rate of helminth, protozoa and mixed

Table 1. Infection rates of helminth and protozoa by gender

Gender	No. of Subjects	Helminth	Protozoa	Mixed infection	Total
Male	137	2 (1.5)	50 (36.5)	6 (4.4)	58 (42.3)
Female	137	3 (2.2)	57 (41.6)	2 (1.5)	62 (45.3)
Total	274	5 (1.8)	107 (39.1)	8 (2.9)	120 (43.8)

Mixed infection means infection with helminth and protozoa.

Each infection rate (%) is shown in parentheses.

infection were 1.8% (5), 39.1% (107) and 2.9% (8) cases among examinee. No significant differences were recognized in the infection rates between males and females, as the rates were 42.3% (58/137) in males and 45.3% (62/137) in females.

Table 2 shows the infection rates of the type of helminth and protozoa by gender and age-group. The numbers of helminths and protozoa detected in all subjects were as follows: 2 (0.7%) *A. lumbricoides*; 6 (2.2%) *T. trichiura*; 6 (2.2%) *Hymenolepis nana*; 1 (0.4%) *Strongyloides stercoralis*; 41 (15.0%) *Giardia lamblia*; 9 (3.3%) *Entamoeba histolytica*: 62 (22.6%) *Entamoeba coli*; 13 (4.7%) *Endlimax nana*; 3 (1.1%) *Iodamoeba buetschlii*. No significant differences in the rates were found between the two age groups in males and females. However, in females, the infection rate of *E. coli* (7.7%) among the group of 15 years and elder was significantly lower compared with that (29.7%) among the other of less than 15 years.

Discussion

In this study, we found 120 parasite-infected people (43.8%). Of these 120 infected people, 5 (1.8%) were infected with helminths, 107 (39.1%) were infected with protozoa, and 8 (2.9%) were infected with both helminths and protozoa.

The helminth infection rates in Bolivia have been previously reported [3], but few reports exist on the protozoan infection rate [12]. Thus, we conducted this study to clarify the helminth and protozoa infection rates in La Paz. The infection rate of helminth (1.8%) was about 1/21 of that (39.1%) of protozoa. Our finding that the helminth infection rate is lower than that of protozoa is related to the unique weather conditions in the study area. Our study area, Asis, is located at an altitude 3,800 meters above sea level, and the annual mean temperature is stable at a low temperature of about 12°C. Generally, helminth eggs are secreted from the body along with people's feces, and they then develop into an infective larva under temperature conditions of more than 25°C [18]. Helminth infections are caused by the ingestion of the infective larva. Therefore, the main reason in the low infection rate of helminth is due to the weather conditions, as helminth eggs are unable to develop into infective larva in such low temperatures.

The infection rates (both 2.2%) of *T. trichiura* and *H. nana* were the highest among the helminths we detected. Of the 6 people infected with *T. trichiura*, 4 were amphiscians living in the Yungus area located at 1,700 meters above sea level, near Asis. The average temperature in Yungus is higher than that in Asis. Under such warmer weather conditions, helminth eggs excreted in feces can easily develop into infective larva, and people are more likely to be infected via the consumption of the embryonated egg. On the other hand, all *H. nana* eggs were detected in children 10 years old or younger. *Hymenolepis* is

Table 2. Infection ratesof the types of helminth and protozoa by gender and age-groups

	Number of Subjects	Helminth				Protozoa				
		Ascaris lumbricoides	Trichuris trichiura	Himenolepis nana	Stercoral strongyloides	Giardia lambria	Entamoeba histolytica	Entamoeba coli	Endolimax nana	Iodamoeba buetschlii
Male										
- 14	124	1 (0.8)	2 (1.6)	4 (3.2)	1 (0.8)	21 (16.9)	3 (2.4)	24 (19.4)	4 (3.2)	1 (0.8)
15-	13	1 (7.7)	1 (7.7)	0 (0.0)	0 (0.0)	4 (30.8)	0 (0.0)	3 (23.1)	0 (0.0)	0 (0.0)
Total	137	2 (1.5)	3 (2.2)	4 (2.9)	1 (0.7)	25 (18.2)	3 (2.2)	27 (19.7)	4 (2.9)	1 (0.7)
Female										
- 14	111	0 (0.0)	1 (0.9)	2 (1.8)	0 (0.0)	13 (11.7)	6 (5.4)	33 (29.7)	8 (7.2)	1 (0.9)
15-	26	0 (0.0)	2 (7.7)	0 (0.0)	0 (0.0)	3 (11.5)	0 (0.0)	2 (7.7)*	1 (3.8)	1 (3.8)
Total	137	0 (0.0)	3 (2.2)	2 (1.5)	0 (0.0)	16 (11.7)	6 (4.4)	35 (25.5)	9 (6.6)	2 (1.5)
Male and Female										
- 14	235	1 (0.4)	3 (1.3)	6 (2.6)	1 (0.4)	34 (14.5)	9 (3.8)	57 (24.3)	12 (5.1)	2 (0.9)
15-	39	1 (2.6)	3 (7.7)	0 (0.0)	0 (0.0)	7 (17.9)	0 (0.0)	5 (12.8)	1 (2.6)	1 (2.6)
Total	274	2 (0.7)	6 (2.2)	6 (2.2)	1 (0.4)	41 (15.0)	9 (3.3)	62 (22.6)	13 (4.7)	3 (1.1)

Infection rate (%) in each age-group is shown in parentheses.

*: p < 0.05 (comparison between female age groups less than 15 years and those of 15 years and elder)

generally found in the feces of rats, and the intermediate hosts are sitophilus or fleas [19]. People are infected with *H. nana* due to the accidental ingestion not only of the feces of infected rats but also of the intermediate hosts. In addition, after the infection, *H. nana* causes autoinfection in the small intestine [20]. For this reason, we considered that children having almost no knowledge on how to protect their health are infected by *H. nana*, and that the infection persists through the autoinfection.

In contrast to helminths, protozoa remain infective for more than 30 days even under low temperature conditions because of encystment [21,22]. Therefore, protozoa are capable of being transmitted to humans and causing infection at any time if the cysts are ingested. This is the main reason that the infection rate of protozoa was higher than that of helminth.

In our study, no significant differences in the infection rates of protozoa were found between males and females or between the two age-groups. Thus, our data showed that protozoal infection is spreading among all age groups. Protozoal infection is transmitted through the ingestion of drinking water or foods containing the cysts. Our data suggest that all of the people living in the study area are vulnerable to protozoal infection due to their frequent contact with the water or foods polluted with sewage. Nevertheless, among females, the infection rate (7.7%) of *E. coli* in age group of 15 years and elder was significantly lower compared with that (29.7%) in the group less than 15 years in age. This lower infection rate may reflect the increased concern regarding health among female high school students and adult women. Thus, it is important to promote health education among the people living in La Paz in order to help preventing parasite infections.

In summary, the people living in Asis had a higher likelihood of infection with protozoa than with helminths. The result of our study induced the strong interest of professional in this area and may contribute to a significant reduction of the parasite infectionrate among school students and adult women. Health education, group faces tests, mass deworming, and the rapid improvement of water and sewage infrastructures are needed to prevent outbreaks of parasitic diseases and preventive measures against protozoa infections should take priority over measures against helminth infections in this area.

Acknowledgment

References

1. Hotez PJ, Bottazzi ME, Franco-Paredes C, Ault SK, Periago MR. The neglected tropical diseases of Latin America and the Caribbean: a review of disease burden and distribution and a roadmap for control and elimination. PLoS Negl Trop Dis. 2008; 2: e300.

2. Hotez PJ. Holidays in the sun and the Caribbean's forgotten burden of neglected tropical diseases. PLoS Negl Trop Dis. 2008; 2: e239.

3. Foster Z, Byron E, Reyes-Garcia V, Huanca T, Vadez V, Apaza L, *et al*. Physical growth and nutritional status of Tsimane' Amerindian children of lowland Bolivia. Am J Phys Anthropol. 2005; 126: 343-351.

4. Hadju V, Abadi K, Stephenson LS, Noor NN, Mohammed HO, Bowman DD. Intestinal helminthiasis, nutritional status, and their relationship; a cross-sectional study in urban slum school children in Indonesia. Southeast Asian J Trop Med Public Health. 1995; 26: 719-729.

5. Gendrel D, Treluyer JM, Richard-Lenoble D. Parasitic diarrhea in normal and malnourished children.Fundam Clin Pharmacol. 2003; 17: 189-197.

6. Hotez PJ, Molyneux DH, Fenwick A, Kumaresan J, Sachs SE, Sachs JD, *et al*. Control of neglected tropical diseases. N Engl J Med. 2007; 357: 1018-1027.

7. Lammie, PJ, Fenwick A, Utzinger J. A blueprint for success: integration of neglected tropical disease control programmes. Trends Parasitol. 2006; 22: 313-321.

8. WHO "Strategic and technical meeting on intensified control of neglected tropical diseases: A renewed effort to combat entrenched communicable diseases for the poor." A report of an international workshop iii-iv; 2006.

9. WHO Working to overcome the global impact of neglected tropical diseases. http://whqlibdoc.who.int/publications/2010/9789241564090_eng.pdf.(Accessed September 1, 2013)

10. Weisbrot M, Sandoval L. Bolivia's economy - An update. Int J Health Serv. 2008; 38:399-402.

11. Tanner S, Leonard WR, McDade TW, Reyes-Garcia V, Godoy R, Huanca T. Influence of helminth infections on childhood nutritional status in lowland Bolivia. Am J Hum Biol. 2009; 21: 651-656.

12. Flores A, Esteban JG, Angles R, Mas-Coma S. Soil-transmitted helminth infections at very high altitude in Bolivia. Trans R Soc Trop Med Hyg. 2001; 95: 272-277.

13. WHO. World Health Statistics 2013. http://www.who.int/gho/publications/world_health_statistics/EN_WHS2013_Full.pdf. (accessed September 1, 2013)

14. UNICEF, WHO, World Bank, UN DESA, UNPD. Mortality rate, under-5 (per 1,000 live births) 2013. http://data.worldbank.org/indicator/SH.DYN.MORT.(accessed September 1, 2013)

15. Gyorkos TW, Maheu-Giroux M, Casapia M, Joseph SA, Creed-Kanashiro H. Stunting and helminth infection in early preschool-age children in a resource-poor community in the Amazon lowlands of Peru. Trans R Soc Trop Med Hyg. 2011; 105: 204-208.

16. Ritchie LS, Pan C, Hunter GW, 3rd. A comparison of the zinc sulfate and the formalin-ether (406th MGL) technique. Med Bull US. 1953; 1: 111-113.

17. Matsuoka H, Yoshida S, Hirai M, Ishii A. Reports of parasitic diseases and entomological cases in the department of medical zoology, Jichi Medical School: accumulated cases from five years. Jpn J Infect Dis. 2001; 54: 148-150.

18. Tsuji N, Fujisaki K. Development in vitro of free-living infective larvae to the parasitic stage of Strongyloides venezuelensis by temperature shift. Parasitology. 1994; 109: 643-648.

19. Fagir DM, El-Rayah el A. Parasites of the Nile rat in rural and urban regions of Sudan. Integr Zool. 2009; 4: 179-187.

20. Beaver PB, Jung RC, Cupp EW. Clinical Parasitology, 9th Ed. Philadelphia. Lea & Febiger 1984; 509-511.

21. Eichinger D. Encystation of entamoeba parasites. Bioessays 1997; 19:633-639.

22. Aguilar-Díaz H, Carrero JC, Argüello-García R, Laclette JP, Morales-Montor J. Cyst and ncystment in protozoan parasites: optimal targets for new life-cycle interrupting strategies? Trends Parasitol. 2011; 27: 450-458.