SEROPREVALENCE AND RISK FACTORS OF HUMAN CYSTICERCOSIS IN A COMMUNITY OF SHANDONG, CHINA

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Abstract. A community-based seroepidemiologic survey on *Taenia solium* cysticercosis in humans was carried out in Shandong Province, China. Blood specimens from 2,898 residents were collected and examined for anti-cysticercus antibody. Information on demographic and potential risk factors was obtained using a standardized questionnaire. The overall seroprevalence of cysticercosis was 3.2%. Seropositivity tended to increase with age ranging from 1.8% in children under 6 years of age to 5.7% in those over 60 years old. Distance between village residence and the town of the community was negatively associated with seropositivity (Chi-square for trend test $p = 0.02$). Multivariate logistic regression analysis identified four risk factors for cysticercosis infection in the community: defecating indiscriminately (OR = 1.35, 95% CI 1.01 - 1.81), being unable to identify diseased pork (OR = 4.09, 95% CI 1.53 - 10.97), raising pigs (OR = 1.36, 95% CI 1.09-1.69), and more than 60 years old (OR = 1.49, 95% CI 1.10 - 2.02. These findings have implications for developing appropriate strategies for the control of *Taenia solium* cysticercosis in the community.

INTRODUCTION

Cysticercosis is a zoonosis widespread in developing countries of Latin America, Africa and Asia (Mahagan, 1982). Humans, the definitive hosts, acquire taeniasis, the intestinal tapeworm after intake of raw or inadequately cooked pork that harbors larval forms (cysticerci). Swine, the intermediate hosts, are infected with cysticercosis by ingesting eggs from the proglottides and feces passed by human tapeworm carriers. Humans can also get cysticercosis by ingesting *Taenia solium* eggs either directly from their own tapeworm infections or indirectly from contaminated hands, food or water. In human hosts, *T. solium* eggs develop into cystic larvae, which invade various organs, frequently central nervous system causing neuro-cysticercosis manifested by epilepsy, hydrocephalus and other severe neurological disorders. Neuro-cysticercosis may lead to prolonged disability and sometimes death (Del Brutto and Sotelo, 1988). The epidemiology of cysticercosis involves various bio-medical, social and behavioral factors. There is increasing interest in studying all possible determinants of the problem as part of the search for an effective intervention (Diaz *et al*, 1992; Sarti *et al*, 1992; Garcia *et al*, 1995).

In Shandong Province, China, *Taenia solium* taeniasis and cysticercosis are commonly seen, and neuro-cysticercosis has been increasingly diagnosed in the past several years (Ge *et al*, 1993). However, the published data are hospital-based and cannot reflect the true magnitude of the problem. To obtain an accurate picture of current epidemiology of taeniasis and cysticercosis, community-based investigations were carried out in the Province (Cao *et al*, 1995). As a part of the provincial survey, the present study aimed to determine the seroprevalence of human cysticercosis, and to identify certain epidemiological factors that might contribute to its occurrence in the community.

MATERIALS AND METHODS

Study area

The study was conducted from July 1992 to October 1993 in a community of Yanzhou city, in the southwestern part of Shandong, China. This area has a temperate climate, with the rainy season from April through October. Most of the inhabitants are Han Chinese engaged in agricultural activities. Pig are usually fed in households. Most pigs are raised for sale, but some are consumed by residents on festival days. Pork is the main source

of animal protein and an important feast dish. Health services are mainly provided by the local government through community health centers and anti-epidemic stations, with supplementation by private practitioners. The primary health care system is undergoing change.

Serologic test methods

Blood samples were obtained from inhabitants who were willing to cooperate. A micro-quantity of blood was collected on filter paper by simple pin-pick of the earlobe. All specimens were screened by an indirect fluorescent antibody (IFA) test to detect anti-cysticercus antibody. The IFA test was developed and described by Wen *et al* (1990), who used frozen sections of *Cysticercus cellulosae* scolex as antigen. Filter paper eluates of blood samples were tested at 1 : 20 dilution and examined with an Olympus fluorescence microscope. Positive and negative control samples were always included in each test. From IFA positive cases, venous blood samples were collected and examined with the enzyme-linked immunosorbent assay (ELISA) described by Baily and co-workers (1988). The antigen used was a crude saline extract of *Cysticercus cellulosae* bladder fluid. Only those positive for both tests were considered as seropositive in order to make a conservative estimation of seroprevalence.

Data collection

An investigation on demographic and potential risk factors was carried out while blood samples were taken. A pre-tested, Chinese-language questionnaire administered to each respondent was used to collect the following information: demographic characteristics (age, sex, occupation, education, residence); eating habit and diet; food preference; personal hygiene; use of latrine; the usual site of defecation; pig ownership; general knowledge related to the infection and its treatment and prevention. For pre-school children and people who were too old to answer the questions, the information was obtained from the principal member of the household.

Statistical analysis

Data were analyzed using EPI-INFO version 6 (Centers for Disease Control and Prevention, Atlanta, Georgia, USA) and SPSS/PC+V5 (SPSS Inc, Chicago, Illinois, USA) to determine the seroprevalence of human cysticercosis. The association between each variable and seropositive result was examined by chi-square or Fisher's exact test. Chi-square test for trend was employed to evaluate age and resident distance from the town for the association with seropositivity. Odds ratio (OR) with 95% confidence interval (CI) was used to estimate relative risk and to assess the strength of association (Fleiss, 1981). Multiple logistic regression analysis was conducted with forward stepwise approach to simultaneously adjust for potential confounders and to assess interactions between variables. Factors included in the logistic regression analysis were selected from those found to be significantly associated with cysticercosis infection at $p < 0.05$ in uni-variate analyses. Adjusted odds ratios were obtained from the final model.

RESULTS

There were a total of 7,161 inhabitants living in 8 villages of the community at the time of our study. Blood specimens were obtained from 2,898 (40.5%) individuals. The proportion of residents selected from each village was not significantly different. Subjects less than 6 years of age were under-represented, of these only 22.0% participated in the study, because many parents refused to let us take blood from their children. The distribution of other age groups was essentially similar to that in the whole population. There was no difference in occupation, educational level and sex ratio between the sampled population and the whole population of the community.

From initial screening of 2,898 filter paper specimens by IFA, 162 (5.6%) showed positive reactions. When venous blood specimens taken from all the IFA positive cases were tested by ELISA, 92 were positive, giving a overall seroprevalence of 3.2% (95% CI 2.5% - 3.8%). Two households, respectively, each had two infected persons. Seroprevalence by demographic characteristics is shown in Table 1. Seroprevalences were similar in male (2.9%) and female (3.3%) subjects, and tended to increase with age ranging from 1.8% to 5.7% ($X^2_{trend} = 3.47$, $p = 0.06$) (age-stratified prevalence is shown in Table 1). Persons

Table 1

Cysticercosis seroprevalence by demographic characteristics of the 2,898 study subjects.

Characteristic	No. seropositive (%)	OR (95% CI)
Age (year) (X^2_{trend} = 3.47, df = 1, p = 0.06)		
≤ 5	3/170 (1.8)	1
6-	9/246 (3.7)	2.11 (0.56, 7.93)
10-	6/315 (1.9)	1.08 (0.27, 4.38)
20-	14/478 (2.9)	1.68 (0.48, 5.92)
30-	24/711 (3.4)	1.94 (0.58, 6.54)
40-	13/472 (2.8)	1.58 (0.44, 5.60)
50-	10/277 (3.6)	2.08 (0.57, 7.69)
6+[a]	13/229 (5.7)	3.35 (0.94, 11.95)
Gender (X^2 = 0.39, df = 1, p = 0.53)		
Male	32/1,098 (2.9)	1
Female	60/1,800 (3.3)	1.15 (0.74, 1.78)
Education (X^2 = 6.81, df = 5, p = 0.23)		
Pre-school children	9/291 (3.1)	1
Illiterate	23/541 (4.3)	1.39 (0.64, 3.05)
Primary school	18/898 (2.0)	0.64 (0.28, 1.44)
Secondary school	35/970 (3.6)	1.17 (0.56, 2.47)
High school	7/196 (3.6)	1.15 (0.42, 3.14)
Bachelor's level	0/2 (0.0)	-
Occupation (X^2 = 5.12, df = 4, p = 0.27)		
Student	8/384 (2.1)	1
Pre-school children	9/304 (3.0)	1.43 (0.53, 3.76)
Farmer	69/2,115 (3.3)	1.59 (0.76, 3.32)
Factory worker[b]	5/71 (7.0)	3.56 (1.13, 11.22)
Others	1/24 (4.2)	2.04 (0.25, 17.04)
Village[c] (X^2_{trend} = 5.24, df = 1, p = 0.02)		
Village 1	17/678 (2.5)	1
Village 2	3/261 (1.1)	0.45 (0.13, 1.56)
Village 3	5/293 (1.7)	0.68 (0.25, 1.85)
Village 4	13/303 (4.3)	1.74 (0.84, 3.64)
Village 5	13/344 (3.8)	1.53 (0.73, 3.18)
Village 6	8/189 (4.2)	1.72 (0.73, 4.05)
Village 7	18/378 (4.8)	1.94 (0.99, 3.82)
Village 8	15/451 (3.3)	1.34 (0.66, 2.71)

[a]Having a higher risk than younger individuals, p = 0.024; [b]Having a significantly higher risk in comparison with students, p = 0.038; [c]Village were numbered in the decrescent order of the distance from Yanzhou city. The reference village (village 1) was the farthest from the city. X^2 for trend test p = 0.02.

over 60 years of age had a significantly higher risk than younger individuals (X^2 = 5.06, p = 0.02). When living villages of respondents were compared, it was found that the distance from the town of the community (Yanzhou city) was negatively associated with seroprevalence (X^2_{trend} = 5.24, p = 0.02), *ie* as the distance increased, fewer people tended to be positive for cysticercosis. The overall difference of seropositivity among occupational groups was not significant, although the factory workers had a significantly higher risk than did students (Fisher's exact test, p = 0.04). Regarding educational levels, the illiterate had the highest positive rate (4.3%), but the differences were not

statistically significant in comparison with all other adults ($X^2 = 2.52$, $p = 0.11$).

The distribution of seropositivity with respect to potential risk factors is demonstrated in Table 2. In this case, one-tailed p-value was calculated. Factors with significance ($p < 0.05$) were defecating indiscriminately rather than in a latrine, pigs being raised in the house of a respondent, inability of respondents to identify cysticercus-containing meat, and using pigsty as a toilet.

Forward stepwise logistic regression was performed with serological result as the dependent variable to test the variables which were significant ($p < 0.05$) in the univariate analyses. In the multiple logistic regression analysis, village of residence was taken as an ordinal variable, and the others were all categorical variables. As a result, four independent factors entered the final model, which were significantly associated with seropositivity. The adjusted odds ratios with 95% CIs for these risk factors are shown in Table 3.

DISCUSSION

Taenia solium taeniasis/cysticercosis is an important public health problem and has been listed in "Envisagement of the goal of parasitic disease prevention by the year of 2,000 in China" (MPHC Scientific Group, 1991). In Shandong Province, the hospital-based data have confirmed the endemicity and the public health significance of the infection (Ge *et al*, 1993). But such data could not reflect epidemiology of the general population and did not allow analysis of the epidemiological factors associated with the infection. The present study, as part of a comprehensive survey, was conducted in a rural community of Shandong Province. Except for the age group under 6 years old, the study sample was representative of the community population. The information on exposure at community level is more realistic than that from hospital-based studies. The findings from the present study provide a basis for inferring the seroprevalence of human cysticercosis in analogous areas as well as for establishing rational control strategies in the community.

Table 2

Potential risk factors and their association with cysticercosis seropositivity (n = 2,898) by univariate analysis.

Factor	No. with factor	No. positive (%)	OR (95% CI)	p*
Eating uncooked vegetable	1,887	57 (3.0)	0.87 (0.56, 1.33)	0.259
Eating unclean fruit	1,421	44 (3.1)	0.95 (0.63, 1.44)	0.407
Drinking unclean water	771	31 (4.0)	1.42 (0.91, 2.26)	0.059
Don't wash hands after defecating	2,207	78 (3.5)	1.02 (0.57, 1.82)	0.476
Eating food with dirty hands	1,920	63 (3.3)	1.11 (0.71, 1.74)	0.323
Defecating indiscriminately†	294	15 (5.1)	1.76 (1.00, 3.11)	0.023
Latrine poorly constructed	994	36 (3.6)	1.24 (0.81, 1.90)	0.161
Fecal matter improperly disposed	2,820	92 (3.3)	α -	0.078
Having raised pigs†	779	35 (4.5)	1.70 (1.11, 2.61)	0.007
Using pigsty as a toilet†	497	24 (4.8)	1.74 (1.08, 2.80)	0.010
Allowing pigs to scavenge human feces	967	31 (3.2)	1.02 (0.64, 1.61)	0.473
Being unable to identify diseased meat†	2,445	91 (3.7)	17.5 (2.4, 125.7)	0.000
Don't know the cause of *T. solium* infection	1,908	56 (2.9)	0.80 (0.52, 1.23)	0.154
Don't know how to treat the infection	1,540	49 (3.2)	0.99 (0.66, 1.51)	0.491
Don't know how to prevent the infection	2,419	80 (3.3)	1.33 (0.72, 2.46)	0.180

*One-tailed p-value by chi-square or Fisher's exact test; Calculation is based on the difference between having the risk factor and without risk factor. †Factors with significance ($p < 0.05$).

Table 3

Risk factors and their associations with cysticercosis seropositivity by multiple logistic regression analysis.

Risk factor	Adjusted OR	95% CI	p
Defecating indiscriminately	1.35	1.01-1.81	0.042
Being unable to identify diseased meat	4.09	1.53-10.97	0.005
Having raised pigs	1.36	1.09-1.69	0.006
More than 60 years old*	1.49	1.10-2.02	0.012

*To compare with those under 60 years of age.

One problem in community-based studies is the lack of field-applicable diagnostic methods (Schantz *et al*, 1989). Computerized tomography (CT) and magnetic resonance (MR) are useful diagnostic tools for human cysticercosis, but they are expensive and generally not available in rural areas of developing countries (Del Brutto *et al*, 1988). In the last decade, there has been increasing reliance on serological tests, which have been considered as an appropriate approach to screening a community for the presence of *T. solium* infections (Diaz Camacho *et al*, 1990). However, one of the difficulties in carrying out seroepidemiologic studies is the collection of blood samples from the general population by using syringe and needle. Therefore, as a screening test, the IFA test was developed, for which only a micro-quantity of blood was collected on filter paper by simple pin-pick of the earlobe. (Wen *et al*, 1990). The practice has testified that IFA testing followed by ELISA test using venous blood is a practical, reliable and effective method for community-based surveys. However, the combination of two tests results in a conservative estimate of seroprevalence. To obtain a more accurate estimation, EITB (enzyme-linked immunoelectrotransfer blot) test would be preferable as a standard in epidemiologic studies (Tsang *et al*, 1995).

The study indicated that human cysticercosis was widely prevalent in the study community with an overall seroprevalence of 3.2%. Because the seroprevalence was conservatively determined, this study estimated the minimum prevalence of cysticercosis in humans in the communtiy. The infection was found in all age groups and tended to increase with age regardless of gender. The seropositive cases were discrete, and clustering of infected individuals was not evident. This is consistent with the findings of studies in Peru (Diaz *et al*, 1992), but contrasts with other surveys which found that infected persons tended to be clustered by household or neighborhood (Starti-Gutierrez *et al*, 1988; Cruz *et al*, 1989; Diaz Camacho *et al*, 1990; Sarti *et al*, 1992). The difference between these studies may be due to different proportion of participation, or reflect differences in cultural behavior (Diaz *et al*, 1992). There was a trend that with increased distance of a village from the town in the community, villagers were less likely to be positive for cysticercosis. But multiple logistic regression demonstrated that living village of respondents was not a significant predictor for seropositivity. So the difference of seroprevalence among villages may be due to uneven distribution of other covariables.

In our study, seropositivity was found to be associated with multiple factors, including lack of knowledge about identifying cysticercosis-infected meat, pig ownership, personal hygienic behavior, and age. Individuals who are unable to identify infected pork have a high risk of seropositivity, because they are liable to get taeniasis by ingestion of cysticercus-containing meat. In the study community, pigs are rarely corralled, and most are permitted to feed freely through villages and have opportunities to scavenge human excrement, so they are more likely to get cysticercosis. Pigs are usually sold to local butchers or slaughtered and consumed by owners and their neighbors. Pork is not formally inspected before consumption. Cysticercosis-positive meat is rarely identified and cannot be properly disposed (Zhu *et al*, 1991). In addition, the roaming pigs also contribute to the dissemination of *T. solium* eggs in the environment.

All these aspects may explain why pig-raising is a prominent risk factor for human cysticercosis. Defecating indiscriminately is an unhygienic habit, which is likely to result in a higher risk of cysticercosis infection. The seroprevalence of cysticercosis tends to increase with age. Multiple logistic regression analysis in the present study showed that persons more than 60 years old had a higher risk of being seropositive. The age-dependent pattern of seropositivity has also been noted in other studies conducted in Mexico (Sarti, 1992, 1994) and Peru (Diaz, 1992; Garcia *et al*, 1995). It is unknown if this is a cohort effect, or more likely, a result of cumulative exposure to *T. solium* infection.

These data should be interpreted in the context of the limitations of the study design. This was a cross-sectional study, so the cause-and-effect relationship could not be directly established. However, these findings have value for developing rational and appropriate approaches to preventing the infection. For the control of cysticercosis, rational intervention programs should be culturally acceptable and within the economic reach of developing countries. The results of present study suggest that in this community, health education would be a proper approach to preventing human cysticercosis. Improvements in pig-raising practices and changes in hygienic behavior would probably reduce the transmission of *Taenia solium* infection.

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