INCREASED PREVALENCE OF CYSTICERCOISIS AND TAENIASIS AMONG PROFESSIONAL FRIED PORK VENDORS AND THE GENERAL POPULATION OF A VILLAGE IN THE PERUVIAN HIGHLANDS

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Abstract. Two different populations in Saylla, a Peruvian village near Cusco, known for chicharrones, a local pork dish, were surveyed by serology and stool examination to determine the prevalence and epidemiologic characteristics of Taenia solium infection. Group I (n = 43), the chicharroneros, were members of families professionally devoted to the making and selling of chicharrones, and Group II (n = 102) was a sample of the general population of the same village. Unlike people in Group I, general villagers only occasionally prepare or sell this food product, and then only to their neighbors or relatives. The prevalence of taeniasis was extremely high (8.6%) for the chicharroneros and 3% for the general villagers. Seroprevalence for cysticercosis by immunoblot was similarly high in both groups (23.3% and 23.8%, respectively). Being female, older than 30, and having daily contact with pork were factors strongly associated with a positive serologic result for cysticercosis in the chicharroneros, whereas males were more frequently seropositive in the general villagers group. Antibody reaction to more antigen bands in immunoblots and neurologic symptoms were more common among the chicharroneros. Also, in the general villagers group, seroprevalence increased with each exposure factor, ranging from 9.4% in individuals who did not raise pigs to 50% in the small subgroup that raised pigs, butchered their own animals, sold pork, and sold chicharrones, suggesting that these activities are related to increased risk for tapeworm or larval infection.

Cysticercosis, an infection by the larval stage of Taenia solium, is endemic in many developing countries.1,2 The life cycle of T. solium includes pigs as the normal intermediate hosts, harboring the larval vesicles or cysticerci, and humans as the definitive host, harboring the adult form or tapeworm (taeniasis). Humans can also serve as the intermediate host and develop the cystic form by accidental ingestion of Taenia eggs.3 Human cysticercosis frequently affects the central nervous system and is a major cause of acquired epilepsy.3,4 Porcine cysticercosis causes important economic losses because of condemnation of infested pork.5

In rural communities of developing countries, poor sanitation and lack of veterinary control provides the conditions (presence of pigs and humans, and fecal contamination) to sustain the life cycle of T. solium. Domestic rearing of pigs is an essential part of the economy of subsistence farmers because pigs are easy to buy and sell, cheaper than other livestock, and if raised free-ranging, require little or no investment in feed. However, this kind of informal pig husbandry not only allows pigs to be exposed to fecal contamination but also permits their uncontrolled slaughtering, bypassing the official slaughter system and resulting in public sale of infested pork, albeit at much lower prices than non-infected pork.5,6

In Latin America, where cysticercosis is endemic, many popular local foods have pork as the principal ingredient (e.g., chicharrones in Peru, carnitas and some tacos in Mexico, and fritada in Ecuador) and are often sold at small stands spread among villages along main roads. People who make their living from the preparation and sales of these local foods generally have daily contact with pork and probably a higher risk for T. solium infection. In this study, we evaluated the prevalence of taeniasis and cysticercosis in two population groups of a village in the highlands of Peru using a serologic test, the electroimmunotransfer blot (EITB) immunoblot assay.7 One group was composed of members from 11 families who operate chicharrones stands. A second group was composed of individuals from families in the same village but were not directly involved in this activity. The prevalence of porcine cysticercosis in the village was also tested using the EITB assay.

MATERIALS AND METHODS

The present survey was conducted with the approval of the Ethics Committees of Universidad Peruana Cayetano Heredia, and Johns Hopkins University. The study was performed between September 1990 and April 1993 in a highland village of Peru, Saylla (population = 562, altitude = 3,200 m above sea level) located about 10 miles from Cusco on a paved road. Saylla is known for chicharrones, a local food made from pork that is first boiled and then deep fried. The chicharroneros stands are located mostly along an inter-state highway, and managed by all members of the family who own them. Families who operate these food stands professionally, also known as chicharroneros, have higher socioeconomic status than do the rest of the community and live in concrete houses, with water, latrines, and sewage connections.
In Saylla proper, houses are built of adobe, with piped water but no sewage connections. Approximately one-third of the houses have latrines. Pig raising is common, usually 1–3 animals per family being kept in the backyard. These families usually slaughter their own pigs for their own consumption, and may occasionally sell pork or even chicharrones, but only to their neighbors and relatives.

**Group I: chicharroneros.** Between September 1990 and June 1991, we contacted the local authorities of Saylla, explained the life cycle and risks of teniasis and cysticercosis to them, and offered to provide testing, health examinations, and treatment of the chicharroneros. Villagers enrolled at this time were assigned to Group I, the chicharroneros. The patient work-up included physical examination, hematocrit, parasitologic stool examination, serologic testing for *T. solium* antibodies (EITB), and antiparasitic treatment for all who tested positive. Prior to the examination we took a census of all roadside food stands in Saylla, recording name, age, and sex of all owner household members, and also whether or not they participate in the preparation of the food sold. Individuals who chose not to give oral consent to participate in the study were excluded. Blood samples were taken by venipuncture, and plastic boxes were provided to each individual for the collection of stool samples. A single stool sample was obtained from each individual. We also provided detailed, specific hygiene and sample management instructions to all donors.

After processing the specimens, we returned to the village to inform the study population about the results. At this time, all individuals with a positive EITB result or *Taenia* eggs in their stool were given a neurologic examination and received a single oral dose of 2 g of niclosamide, followed by a purge with 30 ml of ricin oil after 1.5 hr. Stool samples were again obtained after this treatment and examined for parasitic ova. Seropositive individuals were also offered brain radiographs and referred to a neurologist for further therapy and follow-up.

**Group II: general villagers.** In April 1992, we contacted the Mother’s Club, a civic organization of the village, and they agreed to participate in a similar protocol. Informed consent was obtained from all participants. Persons enrolled at this time were assigned to Group II, the general villagers. A complete census of the village was done, and a general medical examination was provided for free. Blood samples were taken from all volunteers at the time of medical examination. Pregnant women were excluded from the study. Niclosamide therapy was provided to all consenting individuals who had a positive EITB test result, and broad spectrum antihelmintic drugs (albendazole, 400 mg.) were given to the remainder of the participants. Post-treatment stool samples were collected from seropositive individuals. Niclosamide was given to all chicharrones group members because of the high seroprevalence and to exclude all possibilities of leaving a tapeworm infection untreated. On the basis of this and previous studies, we assumed that most tapeworm carriers were EITB positive, and thus gave niclosamide to all seropositive individuals in the general villagers group. Albendazole was given to all other participants to treat other intestinal parasites.

**Pigs.** Examination of pigs was performed in April 1993. After obtaining the owner’s consent, all animals (excluding piglets younger than two months and pregnant sows to avoid the risk of miscarriage) had a blood sample taken from the cava vein. All pigs in the village were sampled, except those for which the owner was not present to authorize the procedure. Hog cholera vaccine was provided to all animals examined.

**Sample processing.** Parasitologic stool examinations were performed at the Universidad Nacional San Antonio Abad in Cusco using the formol-ether sedimentation technique. Sera samples were centrifuged and separated in the field, and sent frozen to the Laboratory of Parasitology of the Universidad Peruana Cayetano Heredia in Lima to be assayed by the EITB assay. Duplicate stool specimens were also examined in Lima for quality control.

The EITB assay was performed as originally described by Tsang and others. Briefly, this assay uses seven purified *T. solium* glycoprotein antigens (diagnostic bands GP50, GP42-39, GP24, GP21, GP18, GP14, and GP13) in an immunoblot format to detect infection-specific antibodies. Reactions to at least one band are considered positive.

**Case definition.** For the purpose of this study, taeniasis or adult tapeworm infection was defined by the presence of eggs in the patients’ stool. Cysticercosis was defined serologically as a positive reaction in the EITB assay.

**Statistical analysis.** Chi-square and Fisher’s exact tests were used to analyze associations between discrete variables. The Student’s *t*-test or Mann-Whitney test was used to analyze differences between continuous variables. The chi-square for trend was used to evaluate the increase in seroprevalence when adding associated factors.

**RESULTS**

**Group I: chicharroneros.** The chicharroneros group was composed of 57 individuals from 10 food stands. Forty-three (75%) agreed to participate and provided blood samples, and 28 of 43 also provided stool samples for parasitologic examination. Males (20 of 43, 46.5%) and females were evenly distributed; ages ranged between seven months and 60 years (mean ± SD = 20.77 ± 14.74). More than half of the population (25 of 43, 58.1%) stated that they were in frequent or daily with raw pork and participate in the preparation of the chicharrones.

Ten individuals (23.3%) had a positive EITB result. Being female (9 of 23 versus 1 of 20; *P* = 0.011), being older than 30 (9 of 11 versus 1 of 32; *P* < 0.001), and having daily contact with pork (10 of 25 versus 0 of 18; *P* = 0.002) were strongly associated with a positive EITB test result. There was at least one seropositive individual from seven of the 10 food stands. Seven of the 10 seropositive individuals in this group reacted to three or more antigen bands on the EITB.

Stool samples from 28 individuals were collected before niclosamide treatment. In addition, 33 post-treatment samples were collected from 40 treated individuals. We found *Taenia sp.* eggs in one (3.6%) of 28 pretreatment samples, and in two (6.0%) of the 33 post-treatment samples, giving an overall prevalence of 8.6% (3 of 35, 26 individuals gave both pre- and post-treatment samples). All three *Taenia* carriers also tested EITB positive for cysticercosis.

Of the 10 seropositive individuals, six reported neurologic
Table 1
Antibodies to *Taenia solium* cystic antigens in relationship to pig-raising habits among general villagers of Saylla, Peru

<table>
<thead>
<tr>
<th>Do not raise pigs</th>
<th>Raise pigs</th>
<th>Also butcher their pigs</th>
<th>Also sell pork</th>
<th>Also sell chicharrones</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>EITB +</td>
<td>Prevalence %</td>
<td>Odds ratio (95% CI)</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>3</td>
<td>9.4</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>21</td>
<td>30.4</td>
<td>4.2 (1.1–23.8)</td>
<td></td>
</tr>
<tr>
<td>60/69</td>
<td>20</td>
<td>33.0</td>
<td>4.8 (1.2–27.4)</td>
<td></td>
</tr>
<tr>
<td>47/60</td>
<td>19</td>
<td>40.4</td>
<td>6.6 (1.6–37.6)</td>
<td></td>
</tr>
<tr>
<td>14/47</td>
<td>7</td>
<td>50.0</td>
<td>9.7 (1.6–68.7)</td>
<td></td>
</tr>
</tbody>
</table>

* EITB = electroimmunotransfer blot. CI = confidence interval.

Symptoms (headache in five, motor seizures in one, paresthesias in three, and dizziness in two), and three gave a history of passing proglottids in their stools. Eight were referred to Cusco, the closest city, for brain radiographs. All eight films were reported as normal by a neuroradiologist.

**Group II: general villagers.** A total of 501 individuals from 96 households were registered in the village census. Age in this population ranged from less than one year to 82 years (mean ± SD = 24.72 ± 22.60), and sex distribution was similar for males (255 of 505, 50.5%) and females. The most common occupations were domestic workers (28.6%), students (28.6%), and those employed in agriculture (14.2%); 11.8% of the persons more than 10 years of age were illiterate at the time of the study. Sixty-one of 96 families (64%) reported raising pigs, 51 butchered their own pigs, 28 sold pork to relatives and neighbors, and eight sold chicharron.

We examined 126 individuals who came for general medical consultation. One hundred one from 62 households agreed to be enrolled into our study (101 of 501, 20%). Each of these persons provided a blood sample for the study. This group was mostly female (73, 72%), and older than those villagers not sampled; most reported raising pigs (69 of 101, 68.3%). Only 37 of these 101 reported neurologic symptoms (mostly headache), and overall seroprevalence in this group was higher than prevalence in those without neurologic symptoms. (13 of 37, 35% versus 11 of 64, 17%; *P* = 0.04, chi-square test).

The EITB+ rate in this group was 23.8%, with more seropositive males than females (11 of 28 males, 40% versus 13 of 73 females, 16%; *P* = 0.04). Age in the seropositive group was slightly higher than those of the seronegative individuals (mean ± SD = 36.46 ± 21.05 versus 32.01 ± 18.64; *P* = 0.47). Seropositive persons belonged to 18 households (29% of sampled households). Significantly, fewer seropositive individuals in this group reacted to three or more bands on EITB than those in Group I (6 of 24 versus 7 of 10; *P* = 0.02).

Seroprevalence increased progressively when we added exposure factors related to pig raising, slaughtering, and pork processing, ranging from 9.4% in individuals who did not raise pigs to 50% in the small subgroup that admitted to raising pigs, butchering pigs, selling pork, and selling chicharrones (Table 1; χ² for trend = 11.62, *P* < 0.001). We collected stool samples from 18 of the 24 seropositive individuals in this group and found *Taenia sp.* eggs in three (17%).

Neurologic symptoms were reported in 37 individuals, mainly headache (33), episodes of loss of consciousness (5), and epilepsy (3). The proportion of persons complaining of headache was similar in seropositive and seronegative individuals (10 of 24, 42% versus 23 of 77, 30%; *P* = 0.11). Two of five individuals who complained of episodes of unconsciousness tested seropositive, as did one of the three of the epilepsy cases. This seropositive epileptic individual was the only one in the study with an abnormal neurologic examination result (lost of coordination and fasciculations in tongue).

**Porcine population.** Fifty three pigs (21 males and 32 females) were sampled, and 19 (35.8%) were positive by the EITB assay. Seroprevalence was similar for both sexes (8 of 21 males, 38.1% versus 11 of 32 females, 34.4%; *P* = 0.99).

**Discussion**

Socioeconomic and behavioral factors are critical in the perpetuation of the *taeniasis/cysticercosis* life cycle. Domestic pig raising with poor animal husbandry is by far the most important of these factors.9-11 The risks associated with this activity, however, are difficult to estimate because of confounding factors that include poor sanitary conditions, and poor knowledge of the parasite life cycle, resulting in sustained consumption of infested pork.12 This study, performed in a cysticercosis-endemic zone, demonstrates that food handlers who specialize in pork preparation are especially at risk for infection with both *T. solium* intestinal tapeworms as well as larval tissue cysts (*cysticercosis*). The increased risk of infection observed in food handlers was especially severe in females, perhaps because they handled raw, infected pork more frequently than did males. Among the food handlers, there was a high proportion who had a positive EITB test result; they reacted to four or more immunoreactive bands, suggesting active *cysticercosis* infection. Clinical cases of active neurocysticercosis (those with viable cysts) react to two or more bands on the EITB,13-15 while persons with inactive neurocysticercosis or persons termed asymptomatic seropositive cases detected in field studies commonly react to only one band.13 Unfortunately, there was no computed tomography scanner in Cusco, and imaging confirmation of the diagnosis of clinical neurocysticercosis or characterization of disease stage was not possible.

The seroprevalence in the general villagers group was also the highest compared with other sites we have sampled in Peru,15 suggesting that the increased contact with killing, butchering, and selling pork is an important risk factor for increasing *T. solium* infection. Different prevalence rates were found for males and females, either because different patterns of contact with pork or because the sample of the general villagers was skewed by the offer of medical attention, resulting in increased proportion of females and older individuals in the sample. This bias, however, cannot explain the persistently increasing odds ratio of seropositivity associated with an increased contact with pigs and pork. Although similar overall seroprevalences were found among chicharroneros and general villagers, chicharroneros had more significant disease than did general villagers. In addition, the high rate of *T. solium* tapeworm infection in this village, at least 3% (17%, demonstrated by antiparasitic treatment in the seropositive individuals), which is 4–8 times higher than usual,10-12,15 suggests that viable cysts were in-
gusted more frequently than that which occurs in most endemic villages. The 3% prevalence rate for taeniasis is based on the assumption that all seronegative individuals did not have a tapeworm. The prevalence of taeniasis may be even higher if we consider that a single stool sample is not as sensitive as three samples for coproparasitologic examination, and that coproantigen testing was not available at the time of the study. The most probable explanation to this would be the consumption of the infected pork that cannot be sold. In contrast, the prevalence of porcine infection in the village was similar to other village populations surveyed.10-12,15

The long cooking time and high temperature of the oil used to prepare chicharrones make it improbable that _T. solium_ cysts in pork would still be alive when eaten.16 Therefore, the risk to consumers of chicharrones was related only to the three locations where the adult tapeworm carriers worked. Increased pork contact may predict increased consumption of undercooked pork by these individuals and subsequent establishment of intestinal infection with the adult tapeworm. This would increase fecal-oral exposure to _T. solium_ eggs for the individuals (external autoinfection) or their close contacts. The association between an increased prevalence of _T. solium_ tapeworm infection and frequent contact with infected pork suggests that food sellers, especially those who deal in pork, should be examined routinely for tapeworms. This examination should include parasitologic and/or coproantigen testing for the presence of adult tapeworms, as well as a serologic EITB test for cysticercosis.

Acknowledgments: We are indebted to the Mother’s Club and City Council of Saylla for their collaboration and hospitality. Albendazole was kindly donated by Smith Kline and French Laboratories (Lima, Peru).

Financial support: This study was funded in part by grant number 1-U01 A135894-01 from the National Institutes of Health, by the IDRC (Ottawa, Canada), and by CONCYTEC and the Hipolito Unanue Foundation (Lima, Peru).

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