mens of praziquantel and oxfendazole were compared, with clear advantages in antiparasitic efficay for oxfendazole, given at 30 mg/kg. The last two experiments confirmed this dosage as the minimal effective dose of oxfendazole, and demonstrated that the death of cysticerci occurs along weeks, with larval viability persisting during the first four weeks after therapy. The important role played by informal pig raising in the economy of subsistence farmers is discussed. A treatment for porcine cysticercosis may be an important addition to control programs, at acceptable costs, and is especially attractive because of its cultural acceptability and its potential for sustainability.

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IMMUNOTHERAPY FOR PORCINE CYSTICERCOSIS

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INTRODUCTION

Cysticercosis is a parasitic disease that results from ingestion of *Taenia solium* tapeworm eggs. When humans ingest these microscopic eggs they may develop cysticercosis, an important cause of disability and mortality in many developing countries,[1] causing 20% of adult-onset epilepsy[2] and filling 12% of neurological hospital beds[3] in Peru. Porcine cysticercosis occurs when pigs ingest *T. solium* eggs and the resultant cysticercotic or 'measly' pork is of greatly reduced value.[4] In the Andean region of Peru, up to 60% of pigs have cysticercosis, contributing to economic hardship and malnutrition.[5] When humans eat infected pork they may develop *T. solium* tapeworms which release further eggs, contaminating the environment and completing the parasitic life-cycle.

Improvements in public health and animal husbandry have led to the virtual eradication of human and porcine cysticercosis in developed countries, but such measures are too expensive for immediate implementation in less developed areas.[6] Vaccination of healthy pigs with cysticercal antigens caused partial protection against porcine cysticercosis[7,8] but a vaccine is not available and may be difficult to implement in endemic regions. In contrast to preven-

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tive measures, an inexpensive treatment for porcine cysticercosis may be sought after and used by owners of infected pigs if it improved animal health, meat yield, and especially if it caused the degeneration of cysticerci in infected meat, thus increasing its value. Our group is evaluating treatments for porcine cysticercosis with drug therapy[9,10] and immunotherapy which may be cost-effective ways of breaking the life cycle of the parasite, preventing human as well as animal disease.

Cysticerci survive within host tissues by evading and modulating host immunity.[7,11] The rationale for immunotherapy is the observation that immunological intervention may alter this host-parasite interaction, causing destruction of cysticerci: pigs infected with two successive doses of *T. solium* eggs paradoxically developed significantly fewer cysticerci than pigs that had been infected with a single dose, implying that re-infection accelerated cysticercus degeneration and absorption.[12] Similarly, re-infection of cows infected with *T. saginata*[13,14] and of sheep infected with *T. hydatigena*[15] caused degeneration of established cysticerci. Furthermore, laboratory[16] and field studies[17] have reported that immunotherapy with cysticercal antigens caused the partial resolution of porcine cysticercosis. These encouraging results led us to further investigate the effect of immunotherapy on porcine cysticercosis in a randomized, controlled and blinded study.

MATERIALS AND METHODS

Twenty-eight privately reared, naturally parasitized pigs that were being sold for slaughter were purchased from Huancayo, a city in the Peruvian Sierra. All pigs were seropositive for cysticercosis and had palpable tongue nodules, implying heavy infection.[18] Swine cholera vaccine was given immediately after purchase, three weeks aclimatization was allowed, during which pigs were fed freely and no other medications were given. The animals were housed together, so the investigators were blind to treatment group. The study was approved by the ethical committee of the Facultad de Medicina Veterinaria of the Universidad de San Marcos.

Immunotherapy

The pigs were randomly divided into four treatment groups:

1. Membrane-enriched antigens (MA), five pigs;
2. Saline control, seven pigs;
3. Aqueous-soluble crude antigens (AA) in adjuvant, nine pigs; and
4. Adjuvant alone, seven pigs.

Group 1, MA was prepared by the method of Molinari, Meza & Tato.[16] In brief, 2,000 *T. solium* cysticerci were homogenized for three seconds, centrifuged at 1,500 g and the pellet was resuspended in 0.02 M phosphate buffer (pH 7.4) containing 0.4% sodium deoxycholate (Merck, Rahway, NJ) and deoxyribonuclease (Sigma, St Louis, MO) at 20 μg/ml and was ground in a mortar. The material was centrifuged at 30,000 g and the supernatant was removed and dialyzed against several changes of 0.02 M phosphate buffer (pH 7.0) for six days. After the material was centrifuged at 30,000 g for 20 minutes, the supernatant was lyophilized. The same amount of antigen was administered as in previous studies:[16,17] a subcutaneous injection of 0.25 mg of protein (in 0.1 ml saline) behind the ear on days one and seven. ***Group 2, saline*** administered in the same way as for group 1, as a control. In order to maximize the expected immune response, a larger dose of AA in adjuvant with a longer interval between doses was also evaluated: ***Group 3, AA in adjuvant*** was prepared by the method described by Estrada and Kuhn.[17] In brief, the supernatant was taken from 2,000 homogenized, sonicated, centrifuged cysticerci and the concentration was adjusted so that 2.4 mg was given in one ml of Freund's adjuvant (Sigma). This preparation was divided into five equal volumes that were injected into different subcutaneous sites on day one and again on day 14. Freund's complete adjuvant was used on day one, Freund's incomplete adjuvant on day 14. The cysticerci used for both MA and AA preparations were dissected from 17 pigs naturally infected in the same region as the pigs we treated with immunotherapy. ***Group 4, adjuvant alone:*** Freund's complete adjuvant alone on day one, followed by incomplete adjuvant alone on day 14, were administered in the same way as group 3.

Haematology and serology

Blood was taken from each pig immediately prior to the first vaccination, in week five and immediately prior to sacrifice for measurement of differential white cell count and electro-immunotransfer blot (EITB) assay.[20] In brief, the EITB assay detects *T. solium* specific antibodies by using seven lentil-lectin purified glycoprotein bands (molecular weight 50, 42-39, 24, 21, 18, 14 and 13 kD) commonly recognized by serum of humans and pigs with cysticercosis.[21,22] A similar immunoblot method[23] was also performed using the same AA that was administered as immunotherapy.