International Journal for Parasitology 41 (2011) 1015–1018

Contents lists available at ScienceDirect

International Journal for Parasitology

journal homepage: www.elsevier.com/locate/ijpara

Rapid Communication

High prevalence of *Taenia solium* cysticercosis in a village community of Bas-Congo, Democratic Republic of Congo

Kirezi Kanobana [a,*,1], Nicolas Praet [b,1], Constantin Kabwe [c], Pierre Dorny [b], Philippe Lukanu [e], Joule Madinga [f], Patrick Mitashi [f], Mirjam Verwijs [a], Pascal Lutumba [d], Katja Polman [a]

[a] *Institute of Tropical Medicine, Department of Parasitology, 2000 Antwerp, Belgium*
[b] *Institute of Tropical Medicine, Department of Animal Health, 2000 Antwerp, Belgium*
[c] *Institut Nationale de Recherche Biomédicale, Département Parasitologie, Kinshasa, Democratic Republic of Congo*
[d] *Institut Nationale de Recherche Biomédicale, Département Epidémiologie, Kinshasa, Democratic Republic of Congo*
[e] *Zone de Santé de Kimpese, Kimpese, Bas-Congo, Democratic Republic of Congo*
[f] *Université de Kinshasa, Département de Parasitologie Tropicale, Kinshasa, Democratic Republic of Congo*

ARTICLE INFO

Article history:
Received 26 May 2011
Received in revised form 28 June 2011
Accepted 29 June 2011
Available online 13 July 2011

Keywords:
Human cysticercosis
Circulating antigen
Democratic Republic of Congo
Epilepsy
Sub-Saharan Africa
Taenia solium

ABSTRACT

Cysticercosis results from tissue infection with the larval stage of the pig tapeworm *Taenia solium*. Infection of the brain may cause neurocysticercosis, the most frequent cause of acquired epilepsy in developing countries. Information on human cysticercosis in the Democratic Republic of Congo (DRC) is scarce and outdated. We believe this is the first reported study on human cysticercosis and epilepsy in a village community of DRC. The proportion of villagers seropositive by ELISA for *T. solium* circulating antigen was 21.6%, the highest figure reported to date. The adjusted prevalence of active epilepsy in the community was 12.7 in 1,000.

Cysticercosis is a poverty-related disease, caused by infection with the larval stage of the pig tapeworm *Taenia solium*. The disease prevails in areas with poor sanitary conditions and close pig-human contact. Humans accidentally acquire cysticercosis by ingestion of embryonated eggs excreted with faeces of carriers harbouring the adult tapeworm in the intestinal tract (taeniasis). Pigs are the main intermediate hosts and acquire infection through their coprophagic behaviour when they are free-roaming. The hatched larvae migrate throughout the body of humans and swine, invading mostly muscles and encysting to form larval cysticerci. The larvae can also reach s.c. tissues or eyes; a specific tropism has been observed for the CNS leading to neurocysticercosis. Taeniasis in humans is acquired by ingestion of raw or undercooked pork infected with cysticerci.

Neurocysticercosis, caused by infection of the brain, is the most frequent cause of epilepsy in the developing world, accounting for up to 50% of the acquired epilepsy cases in areas of high endemicity (Preux and Druet-Cabanac, 2005). Cysticercosis is a serious public health and agricultural problem in Latin America, Asia and many countries of sub-Saharan Africa (SSA).

The Democratic Republic of Congo (DRC) is one of the largest African countries, surrounded by countries that are known to be endemic for cysticercosis (Phiri et al., 2003; Zoli et al., 2003). DRC is also one of the poorest countries worldwide with a human development index (HDI) ranked as 177 out of the 178 countries listed (United Nations Development Programme, Human Development Report 2010, http://hdr.undp.org/en/reports/global/hdr2010). However, data on human cysticercosis in DRC are scarce and outdated. Only two case reports have been published, and those were issued more than five decades ago. The first report described a single case of neurocysticercosis (Janssen, 1955). The second one reported on seven cases of cysticercosis encountered in a period of 15 months, in the territory of Madimba, Bas-Congo. In the latter study, cysticerci isolated from the patients were all located either subcutaneously or intramuscularly (Pieters, 1955).

More data are available on porcine cysticercosis in the DRC, with some reports from abattoir surveys highlighting the presence of the disease in the country and its potential importance for public health (reviewed by Fain, 1997). A recent epidemiological study on porcine cysticercosis in urban markets where pork is sold and rural villages where pigs are traditionally reared, demonstrated that

* Corresponding author. Tel.: +32 3 2470769; fax: +32 3 2476359.
E-mail address: kkanobana@itg.be (K. Kanobana).
[1] These authors contributed equally to the manuscript.

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doi:10.1016/j.ijpara.2011.06.004

porcine cysticercosis is widespread in the country, with estimated prevalences of infection with viable cysts ranging from 25% to 40% (Praet et al., 2010a).

Based on these concerning figures, we carried out a cross-sectional study on human taeniasis/cysticercosis in one of the villages previously targeted in the porcine cysticercosis study (Praet et al., 2010a). The village of Malanga (5°33′S and 4°21′E) is located 16 km from Kimpese (Bas-Congo), a small city 220 km west of Kinshasa city. The village is divided into six different districts (Malanga gare (MG), Malanga Quartier 1 (MQ1), Malanga Quartier 2 (MQ2), Malanga Quartier 3 (MQ3), Camp Militaire (CM) and ICB (old wood factory settlement)). Crop and livestock production represent the most important activities. Water supply depends on the proximity of a river, roads are not paved and there is no electricity. At the time of census the population comprised approximately 1,250 individuals. Free roaming pigs were identified, as well as a lack of (properly used) latrines, both well-known risk factors for cysticercosis. In the same community, Praet et al. (2010a) reported that 34.8% (95% Confidence interval (95% CI): 23.7–47.2) of the pigs were positive for circulating *T. solium* cysticercosis antigen (Ag) and 2.9% (95% CI: 0.35–10.1) by tongue inspection.

The survey was carried out in August 2009 and targeted all villagers above 1 year of age. Upon informed consent, participants were asked to provide a stool sample for diagnosis of taeniasis by parasitological examination and a blood sample for serological detection of circulating Ag to cysticercosis by Ag-ELISA (Dorny et al., 2004). Seropositivity in the Ag-ELISA was defined as a ratio (i.e. O.D. divided by cut off value) >1 and indicative for the presence of viable cysts and thus current infection with the parasite. The applicability of the Ag-ELISA to provide information on the history of exposure is more limited. The assay has been reported to have a sensitivity of 94.4% and a specificity of 100% in a clinical setting (Erhart et al., 2002). More recently, Bayesian analysis comparing three serological methods yielded estimates of 90% sensitivity and 98% specificity for the diagnosis of current cysticercosis infection by Ag-ELISA in an endemic population (Praet et al., 2010b).

All participants in the study were also submitted to a validated screening questionnaire for the detection of epilepsy. Individuals with a positive result in the ELISA and/or responding positively to the questionnaire received an in-depth investigation, consisting of a neurological examination and an interview to obtain a description of the seizure by the patient and at least one witness. Due to limited resources and restricted accessibility (only feasible in Kinshasa, 236 km from Malanga), electroencephalogram (EEG) and neuroimaging were only offered to patients when considered indispensable for a reliable diagnosis of the cause of seizure, which is often the case in resource poor countries (Winkler et al., 2010). Seizures were classified according to the guidelines of the International League Against Epilepsy; active epilepsy was defined as having at least one epileptic seizure during the past 5 years, regardless of anti-epileptic drug treatment (ILAE, 1993). Patients who were positive for taeniasis, as well as their family members, were offered a treatment with praziquantel (10 mg/kg) and ricin oil. Treatment for taeniasis was done within hospital settings under the supervision of a general physician and an internist. Anti-epileptic treatment was offered to all patients with confirmed epilepsy. All treatment was free of charge. The study was approved by the Internal Review Board of the Institute of Tropical Medicine in Antwerp, Belgium, the Ethics Committee of the University Antwerp, Belgium and the Ethics Committee of the University of Kinshasa, DRC.

A total of 1,014 individuals (>80% of census population) were enroled in the study, of whom 970 (95.6%) provided a blood sample. After exclusion of individuals with incomplete files, a total of 943 individuals were included for a full case analysis. Males and females, and children (<16 years of age) and adults (>16 years of age) were equally represented within the study populations. Stool samples were collected from 816 participants.

Statistical analyses were conducted in STATA 10 IC software (Stata Corp., College Station, TX, USA). A survey proportion calculation was used to account for a clustering effect at household level. Multivariate logistic regression was used to investigate the relation between current cysticercosis infection, sex (M = male versus F = female), village district (MG, MQ1, MQ2, MQ3, CM and ICB) and age as a continuous variable. In addition, the age variable was divided into nine categories of 10 years each, in order to identify changes in positivity frequencies as a function of the age of the individuals. A change point analysis was used to simplify the observed relations into Ag prevalence patterns as a function of age (Praet et al., 2010c). The significance level was set at $P < 0.05$ for all analyses.

Coprological examination revealed *Taenia* eggs in three individuals (0.33% (3/816)). The low measured prevalence of taeniasis may in part be caused by the use of coprological examination, a diagnostic method which is known to have low sensitivity. The copro-Ag by ELISA for taeniasis is estimated to be two to 10 times more sensitive (Allan et al., 1992). A careful extrapolation suggests that a better estimate of the prevalence of taeniasis in this study population would be in the range of 1–2%. A differentiation between *Taenia saginata* and *T. solium* was not conducted. However, based on the absence of cattle in the area and very limited beef consumption by the local population (personal observations), we did not expect a high number of *T. saginata* cases.

The proportion of individuals with a positive result in the Ag-ELISA was 21.6% (95% CI: 18.3–25.0), which is the highest estimated prevalence of current cysticercosis infection reported in a community to date. Results per sex and village district are given in Table 1. Logistic regression analysis revealed a significantly higher proportion of infections in males (26.2% (95% CI: 21.7–30.6)) than in females (17.4% (95% CI: 13.8–21.0)). In addition, the proportion of individuals infected with viable cysts was markedly higher in one village district (MQ1) compared with the remaining village districts (24.4% (95% CI: 17.2–32.8) versus 21.8 (18.9–24.8), $P = 0.057$). Our data are in line with observations by others (Prado-Jean et al., 2007; Carabin et al., 2009). Gender associated and spatial differences in the distribution of cysticercosis infection have been proposed to be indirectly related to risk factors for the disease such as, for example, the close presence to a *Taenia* carrier, a relatively lower number of latrines per person or a relatively higher pig/human ratio in one part of the village, among others (Prado-Jean et al., 2007; Carabin et al., 2009).

Our results also follow the trend of the increasing prevalence of Ag to *T. solium* cysticercosis in SSA. Recently reported data point to prevalence figures of current cysticercosis infection of up to 11.6% in Burkina Faso (Carabin et al., 2009), 16.7% and 14.5% in Tanzania and Mozambique, respectively (Willingham et al., 2009). All numbers are higher compared with previously reported figures in the continent (reviewed by Phiri et al., 2003; Zoli et al., 2003).

Change point analysis showed that the proportion of individuals with current cysticercosis infection significantly increased above the age of 70 (Odds Ratio: 2.8 95% CI: 1.14–3.81) (Fig. 1). Interestingly, similar findings were reported from a community-based study conducted in Ecuador, with a change point leading to a higher proportion of individuals with current cysticercosis infection at the age of 60 years (Praet et al., 2010b). The authors suggested that the higher proportion of infections with viable cysts in older individuals could be attributed to immunosenescence, with a decreased ability of the immune response to react adequately to the parasite. Older individuals tend to have a lower number of T-cells and these cells are hyporesponsive when exposed to Ags (Kumar and Burns, 2008). T-cells and T-cell responsiveness are known to be involved in the immune response against *T. solium*

Table 1
Distribution of the population (numbers) and results of the antigen (Ag)-ELISA for detection of current cysticercosis infection (its prevalence estimates including 95% confidence interval (95% CI)) at population level (village), gender (M = Male, F = Female) and district level (Malanga gare (MG), Malanga Quartier 1 (MQ1), Malanga Quartier 2 (MQ2), Malanga Quartier 3 (MQ3), Camp Militaire (CM) and ICB (old wood factory settlement)).

	Number	Seropositive in Ag-ELISA	
		Proportion	% (95% CI)
Village	943	204/943	21.6 (18.2–25.0)
Gender			
M	435	115/435	26.4 (21.8–31.1)
F	508	89/508	17.5 (13.8–21.2)
Per district			
MG	163	34/163	20.8 (12.3–29.4)
MQ1	146	43/146	29.4 (20.2–38.7)
MQ2	207	38/207	18.4 (11.4–25.3)
MQ3	193	31/193	16.1 (9.5–22.6)
CM	130	29/130	22.3 (13.7–30.9)
ICB	104	29/104	27.9 (17.8–38.0)

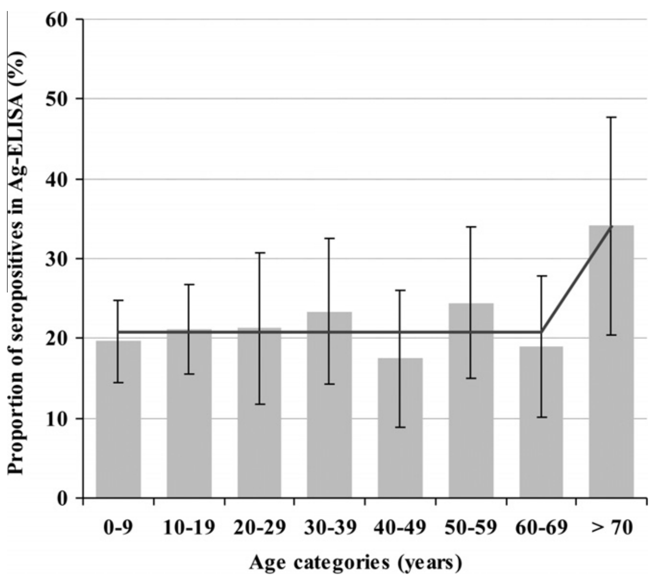

Fig. 1. Proportion of individuals seropositive in the antigen (Ag)-ELISA (and thus with current cysticercosis infection) (grey bars) as a function of age categories of 10 years each, including the predictions resulting from logistic regression (black line). The last age category (>70) includes one individual of 80 years. Upper and lower exact 95% binomial confidence intervals are represented through error bars. Current cysticercosis infection was defined by a positive result (ratio of O.D. divided by cut-off >1) in the ELISA for the detection of circulating antigen.

(Fleury et al., 2010). The decrease in such a response could facilitate larval establishment and promote longevity of cysticerci at greater ages.

Two hundred and thirty-eight individuals (out of the 315 invited, whom had either a positive response to the epilepsy questionnaire (n = 111), a positive response in the Ag-ELISA (n = 174) or both (n = 30)) were present at the time of the in-depth neurological investigation. Absenteeism was caused by reasons such as death (n = 2), moving away from the village (n = 25) or temporary absence (holidays, illness or other, n = 39). Epilepsy was confirmed in 14 individuals, of whom 12 had active epilepsy. For nine out of the 14 cases with confirmed epilepsy, the origin of the seizures could be classified: in five cases the origin was primary focal and in four cases generalised. The main characteristics of the individuals with active epilepsy are given in Table 2. The age of onset of epilepsy ranged between 2 and 56 years of age (mean ± S.D.: 19.5 ± 17.8). The mean age of onset was slightly higher for the focal epilepsy cases (mean ± S.D.: 21.1 ± 20.0) compared with the generalised epilepsy cases (mean ± S.D.: 17.7 ± 17.5), but the difference was not significant. Our observations resulted in an adjusted prevalence of epilepsy of 12.7 in 1,000 (95% CI: 6.6–22.1).

Table 2
Characteristics of individuals included in this study with active epilepsy confirmed by neurological investigation.

	Number
Type of epilepsy	
Partial	5
Generalised	4
Unknown	3
Screening questionnaire epilepsy	9[a]
Seropositive in Ag-ELISA	6
Age	
0–9 years	2
10–19 years	3
>20 years	7
Age of 1st seizure[b]	
0–9 years	3
10–19 years	5
>20 years	3
Duration of epilepsy[b]	
0–5 years	6
6–10 years	2
>10 years	3

[a] Three individuals were also seropositive in the antigen (Ag)-ELISA.
[b] One 11 year old girl with an unknown cause of epilepsy; the age of onset or the duration of epilepsy could not be confirmed by her mother.

Despite the high proportion of people with current cysticercosis infection within the community, the proportion of individuals with active epilepsy was within the range of what has been reported for SSA (Preux and Druet-Cabanac, 2005; Winkler et al., 2010). Seropositivity to the Ag-ELISA may or may not be associated with clinical disease; however, the high proportion of infection with viable cysts suggests hyper-endemicity of cysticercosis in the area and the number of epilepsy cases could be expected to be proportionally higher. Studies on epilepsy have not yet been conducted in the area, and its etiologies are thus not well characterised. We may assume a predominance of causes previously reported in other regions of SSA such as head injuries, perinatal complications, infectious diseases and brain tumours amongst others (reviewed by Preux and Druet-Cabanac, 2005). However, more studies are needed to better estimate the causal association with epilepsy and progression of disease. Also, the contribution of neurocysticercosis to the cases of active epilepsy diagnosed in the current study still needs to be established. Possibly, the relative contribution of extraneural CC to the overall prevalence of active CC is important in this setting.

Subcutaneous cysticercosis is rare in Latin America but believed to be more common in Africa and Asia (Garcia et al., 2003), although information on its incidence in Africa is scarce. Recently, in Uganda, cysticercosis was suggested to account for the presence of s.c. nodules previously erroneously attributed to onchocerciasis (Katabarwa et al., 2008). Although published more than five decades ago, the report on human cysticercosis in Madimba suggests that s.c. cysts were a common manifestation of human cysticercosis in the same area (Pieters, 1955). We cannot preclude that the latter observations were due to a depressed immune state of the people investigated due to concomitant diseases or food deprivation, thereby facilitating the establishment of cysts elsewhere than in the brain which is the immune privileged site (Garcia et al., 2003).

In conclusion, the data presented here point to the detection of an endemic focus of human cysticercosis in DRC with the presence of infection with viable cysts in more than 20% of the population, which is high compared with observations made in other parts of the world. More studies are needed to reliably assess the magnitude, course and determinants of taeniasis/cysticercosis in DRC. This information will be crucial in the identification of sustainable control interventions tailored to this particular setting.

This study provides important information on a disease which has been neglected in the sub-Saharan continent during past decades (Hotez and Kamath, 2009). We hope that it will stimulate researchers in the continent to share their findings and to launch initiatives for consorted actions to improve understanding of the epidemiology of taeniasis/cysticercosis in SSA. Such data could contribute to the development of guidelines to establish criteria, strategies and operative techniques to apply preventive and control measures in the population, an approach which has proven to be successful in a previously endemic country such as Mexico (Flisser and Correa, 2010).

Acknowledgments

The authors thank Bjorn Victor and Famke Janssen for their assistance with the ELISA for circulating antigen. Dr. Thierry Matonda is thanked for conducting the neurological investigations. The team of the Health Zone of Kimpese (Democratic Republic of Congo (DRC)) is acknowledged for its contribution to the field work. We thank the population of Malanga (DRC) for their participation in this study. This work was funded by the Belgian Development Cooperation within the Framework Agreement Programme 3 between the Institute of Tropical Medicine, Antwerp and the Belgian Development Cooperation. A travel grant for Kirezi Kanobana was obtained from the Fonds Wetenschappelijk Onderzoek Vlaanderen.

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