

REVIEW

TAENIASIS/CYSTICERCOSIS IN CHINA

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Abstract. This review concerning the status of taeniasis/cysticercosis in China has been compiled from various reports of studies conducted over the past 30 years, most of which have appeared in national publications in Chinese. Previous hospital reports and epidemiologic surveys have indicated that taeniasis/cysticercosis has been distributed throughout 671 counties in 29 provinces or prefectures of China. There are an estimated three million cysticercosis cases nationwide, while *Taenia asiatica* has presently been confirmed by DNA typing as occurring in Sichuan, Yunnan, and Guizhou Provinces. Although efforts to reduce transmission of taeniasis/cysticercosis have occurred in most endemic areas over the last 30 years, reports conducted over the past 15 years in southwest China have indicated that cysticercosis is emerging as a serious public health problem in this area. The most recent available information on this food-borne parasitic disease, from a Tibetan population in Sichuan, is presented in this review. In addition, recommendations for a national surveillance program for cysticercosis are discussed.

INTRODUCTION

Human taeniasis refers to food-borne infections with adult tapeworms: *Taenia solium*, *Taenia asiatica* (from pigs), or *Taenia saginata* (from bovines). Cysticercosis is a tissue infection with the larval cysticercus or metacestode stage of tapeworms, and occurs most commonly in pigs and cattle. The larval stage of *Taenia solium* can also infect humans and cause cysticercosis/neurocysticercosis, which is considered widespread in the developing countries of Latin America, Africa, and Asia (Del Brutto, 1999; Murrell, 2005). *T. solium* taeniasis/cysticercosis is particularly prevalent in rural areas and is associated with poverty and poor sanitation; where raw or undercooked pork is consumed, and scavenging pigs have access to human feces (Sarti *et al*, 1992; Pawlowski and

Murrell, 2001; Burneo and Garcia, 2002). In endemic areas, neurocysticercosis is an important contributor to neurological morbidity (Garcia *et al*, 1991), and the major cause of acquired epilepsy in the world (Commission on Tropical Diseases, 1994).

It is accepted that human taeniasis and cysticercosis are present in Asia and the Asian-Pacific region (Ito *et al*, 2006). *T. solium* occurs in several Asian countries, including China, India, Indonesia, Thailand, Lao PDR, Cambodia, Nepal, Philippines, Myanmar, Vietnam, and Korea, where local people consume undercooked/raw pork (Singh *et al*, 2002). In China, the emergence of cysticercosis as a serious public health problem was recognized by the Chinese Government. Therefore, intervention measures for taeniasis/cysticercosis control have been carried out since the 1970s in some endemic areas, such as Helongjiang, Jilin, Henan, and Fujian Provinces, where mass screening and treatment for taeniasis carriers, treatment of cysticercosis patients and pigs, enhancement of meat inspection, and population education programs were conducted. Consequently, infection of taeniasis and prevalence of cysticercosis in humans and swine in these endemic areas were reported to be

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greatly reduced (Table 1) (Sun *et al*, 1984; Sun, 1995; Xu *et al*, 1998). Since the open-market policy was implemented nationwide after 1989, there have been great increases in the numbers of small private butchers and slaughterhouses without strict meat inspection. Since then, more and more cases of taeniasis/cysticercosis have been recorded in provincial hospitals. For example, 4,504 cases of cysticercosis that originated from Jilin Province were identified in local hospitals during 1987-1994, while about 2,528 cysticercosis patients were reported from the Affiliated Hospital of Shandong Province during 1991-2002 (Liu *et al*, 1997; Li *et al*, 2004).

The purpose of this review is to make national authorities, scientists, and the international community aware of the emerging situation concerning human cysticercosis and other zoonotic *Taenia* infections in China. Furthermore, the most recent information available on taeniasis/cysticercosis in Tibetan populations in Sichuan Province, southwest of China, is presented.

EPIDEMIOLOGY

Previous epidemiological surveys and hospital reports on taeniasis/cysticercosis have indicated an extensive distribution of this disease in almost all the country's 29 provinces or autonomous regions; with highly endemic areas in northeast, north, central, northwest, and southwest regions (Xu *et al*, 1999; Ito *et al*, 2003; Murrell, 2005). The impact has been estimated at about 3 million cysticercosis cases and US\$ 121 million of annual economic loss in pork production nationwide

(Xu, 2002).

Northeast region

Taeniasis/cysticercosis was previously known to be highly endemic in Helongjiang, Jilin, and Liaoning Provinces several decades ago. Active control intervention measures have been implemented in these areas under the government's supervision since the 1970s, which resulted in the current lower endemicity. In Helongjiang Province, during the period of 1975 to 1980, 1,551 *Taenia* carriers were detected and treated, and 1,571 *Taenia* worms were collected in Fuyu County (Sun *et al*, 1984), while treatment of 4,211 *Taenia* cases and collection of 4,311 tapeworms during 1974 to 1991 was recorded in Tailai County (Li and Yang, 1993). Recent information from a study conducted in Harbin and Nehe Counties during 1993 to 1994 revealed that human cysticercosis seropositivity, tested by indirect hemagglutination test (IHA), ranged from 2.29% to 4.32% (Table 1) (Li *et al*, 1996; Ji *et al*, 1996). By the end of 1991, a total of 138,419 cases of taeniasis were treated and 140,984 tapeworms (of which 17,321 were identified as *T. saginata*) were obtained from across Jilin Province. Infection of human taeniasis reduced from 0.0585% in 1983 to 0.0081% in 1993 (Table 1) (Sun, 1995). Infection of human taeniasis in Dalian District of Liaoning was reported to decrease from 0.72% in 1980 to 0.039% in 1995 (Li *et al*, 1996), while another study in this Province during 1995-1997 disclosed a taeniasis prevalence of 0.0485% (38/78,274) and a prevalence of human cysticercosis of 0.0345% (27/78,274) (Table 1) (Li *et al*, 1998).

Table 1
The status of taeniasis/cysticercosis in some endemic areas of China.

| Province | Year | Taeniasis % | Cysticercosis % | | Reference |
|----------------|-----------|-------------|-----------------|------------|---------------------------|
| | | | Seropositivity | Prevalence | |
| Helongjiang | 1993-1994 | - | 2.3-4.3 | - | Li <i>et al</i> , 1996 |
| Liaoning | 1995-1997 | 0.05 | - | 0.03 | Li <i>et al</i> , 1998 |
| Jilin | 1993 | 0.008 | - | - | Sun, 1995 |
| Shandong | 2000 | 0.05 | - | 0.06 | Liu <i>et al</i> , 2002 |
| Qinghai | 1997-1998 | 0.4 | 14.7 | - | Wu <i>et al</i> , 2001 |
| Inner Mongolia | 1996-1998 | 0.8 | 10.8 | 0.1 | Zhang <i>et al</i> , 2000 |

North Region

A serological survey of human cysticercosis in three regions of Shanxi, Hebei, and Inner Mongolia, conducted in 1992, indicated that 328 (0.76%) individuals were seropositive for anti-*T. solium* metacestode antibodies, and the highest seropositivity was observed to be 2.1% recorded in Inner Mongolia. In addition, 351 of 43,220 subjects (0.81%) reported epileptic seizures. Of these, 102 (29.1%) were observed to be seropositive for antibodies to *T. solium* cysticerci. Furthermore, 0.44% of individuals reported expulsion of *Taenia* proglottids, and 0.52% subjects were identified to have subcutaneous nodules (Wei *et al*, 1994). A hospital survey in Inner Mongolia reported by Zhang Bin found that 814 cysticercosis patients were recorded in a Zhelimu hospital from 1994 to 1995, with case distribution over 41 counties (Zhang *et al*, 2000). An epidemiological survey conducted at 10 study sites in 5 cities in Inner Mongolia during 1996 to 1998 found that 10.78% (441/4,092) individuals were seropositive for *T. solium* cysticerci antibody by IHA, with the range 2.72% to 26.36%. Additionally, 5 persons (0.12%) were identified as having cysticercosis and 33 (0.81%) subjects were confirmed to be *Taenia* carriers by microscopic fecal examination (Table 1) (Zhang *et al*, 2000). Ikejima *et al* (2005) also published clinical and serological data of *T. solium* cysticercosis patients in Inner Mongolia.

Northwest Region

More data are available from Qinghai Province than other provincial regions in the northwest, such as Shaanxi, Gansu, and Ningxia. An epidemiological survey performed during 1997 to 1998 in Huzhu County of Qinghai Province found that 0.39% (4/1,024) individuals were *Taenia* eggs positive by Kato-Katz. Furthermore, 14.71% (159/1,081) were seropositive for *T. solium* cysticercus antibody by ELISA, and 0.56% (6/1,081) residents reported symptoms that were considered to indicate cysticercosis (Table 1) (Wu *et al*, 2001). During 2002 to 2004, another coproparasitological study was conducted more widely in eastern Qinghai Province and recorded a taeniasis prevalence of

0.08% and 1.64% cysticercosis seroprevalence among 5,943 individuals in this area (Wu *et al*, 2005).

Central Region

Taeniasis/cysticercosis appears to be widely distributed in the central region of China, including Shandong, Henan, Anhui, and Hunan Provinces. Due to active control measures conducted in these regions, human prevalence of taeniasis/cysticercosis was greatly reduced. For example, a survey in Shandong Province during 1997-2000 indicated a *Taenia* prevalence of 0.048%, a cysticercosis prevalence of 0.057%, and a seropositivity of IgG4 against *T. solium* cysticerci of 1.91% (Table 1) (Liu *et al*, 2002), in comparison with 0.30% and 0.71% for *Taenia* infection and cysticercosis prevalence, respectively, obtained during the 1990s in the same area (Cao *et al*, 1995). A prevalence range of taeniasis of 0.04% to 1.01% was reported from Henan Province at the end of 1980s, where an incidence of human cysticercosis of 0.6% was also recorded (Zhang *et al*, 1991; Tian *et al*, 1994). In a 2001 survey performed in 2 million residents in Luohe County of Henan Province, only 6 persons were diagnosed as *Taenia* carriers and 26 individuals were confirmed to have cysticercosis, which indicated that parasite transmission had reduced compared to the status 10 years prior (Li *et al*, 2003b). Very limited data are available from Anhui Province. A survey conducted in a mining area of south Anhui indicated that 14 (0.95%) individuals were seropositive for *T. solium* cysticercus antibodies, of which 12 (0.81%) were confirmed microscopically to be *Taenia* carriers (Wang, 2002).

Southwest Region

Sichuan, Yunnan, and Guizhou Provinces are located in this region, with a total population of about 160 million, of which 30 million people belong to ethnic minorities. The western part of Sichuan Province is situated on the Tibetan Plateau, while Yunnan and Guizhou Provinces lie on the Yun-Gui Plateau, the fourth biggest Plateau in China. Previous reports indicated a very high endemicity of taeniasis/cysticercosis in this region.

A 1988-1991 mass survey covering 53,061 individuals from 28 counties of Yunnan Province, using microscopic fecal examination, indicated a widespread occurrence of taeniasis in 15 counties with an average prevalence of 0.9%, the highest prevalence of 17.4% was recorded in Lanping County, where ethnic Pumi populations reside. In addition, a taeniasis prevalence of 4.1% was recorded for the Dali area, mainly inhabited by ethnic Bai and Han Chinese (Zhang *et al*, 1994). Another village-based survey on taeniasis in ethnic Bai populations of Dali Prefecture with fecal examination found a taeniasis prevalence range of 13.2%-19.5%, and an additional 0.5% individuals were diagnosed with cysticercosis by biopsy of subcutaneous nodules (Table 2) (Fu *et al*, 1994; Fang *et al*, 1995). In a community-based survey in an ethnic Yi community of Dali Prefecture, 121 fecal samples were examined microscopically, and 34.7% were positive with *Taenia* eggs. The frequent consumption of raw pork was strongly related to the infection (Table 2) (Fang *et al*, 2002). In 2002, Du *et al* (2002) reported that 67% of 521 subjects in Lanping County (Yunnan) had expelled *Taenia* tapeworm proglottids during the previous three months, and a strong correlation between

Taenia carriers and consumption of raw pig liver was observed, that is, 78.5% of subpopulations who consumed raw pig liver reported a history of *Taenia* proglottid expulsion, compared to 38.0% to those who didn't eat raw pig liver. The species of *Taenia* worms obtained from Lanping County were subsequently identified as *T. asiatica* by molecular DNA analysis (Zhang *et al*, 1999; Wang and Bao, 2003). In addition, both *T. solium* and *T. asiatica* were confirmed to exist in the Dali area of Yunnan Province (Wang and Bao, 2003). During the period 1991-1996, 1,086 cases of cysticercosis were recorded in the Affiliated Hospital of the Dali Institute of Schistosomiasis Prevention and Control, which originated from 12 counties of Dali Prefecture, with ethnic Bai (59.2%) and Han Chinese populations (34.8%) as the dominant patient groups (Luo *et al*, 1998).

A survey of porcine cysticercosis by postmortem inspection was conducted in 12 counties of Dali Prefecture during the period 1990-1995. The results indicated a wide distribution of this infection in all study areas, with an average prevalence of 0.87% to 3.86% recorded in pigs from Binchuan County (Table 3) (Wei *et al*, 1997).

Table 2
Infection of taeniasis (microscope) in Dali Prefecture, Yunnan Province.

| Year | Locality | No examined | No positive | % | Reference |
|------|---------------------|-------------|-------------|------|--------------------------|
| 1992 | Dali (ethnic Bai) | 653 | 86 | 13.2 | Fu <i>et al</i> , 1994 |
| 1993 | Eryuan (ethnic Bai) | 753 | 147 | 19.5 | Fang <i>et al</i> , 1995 |
| 2000 | Dali (ethnic Yi) | 121 | 42 | 34.7 | Fang <i>et al</i> , 2002 |
| | Total | 1,527 | 275 | 18.0 | |

Table 3
Infection of porcine cysticercosis (postmortem inspection) in Dali Prefecture, Yunnan Province during 1990-1995.

| Locality | No examined | No positive | Infection % |
|----------|-------------|-------------|-------------|
| Dali | 489,034 | 2,285 | 0.5 |
| Binchuan | 72,236 | 2,791 | 3.9 |
| Weishan | 183,488 | 5,095 | 2.8 |
| Eryuan | 126,941 | 1,583 | 1.3 |
| Total | 871,699 | 11,754 | 1.3 |

Previous hospital reports from Sichuan Province indicated a distribution of taeniasis/cysticercosis that centered in the "ethnic minority" regions, which include Ganze Tibetan Prefecture, Aba Tibetan and Ethnic Qiang Prefecture, Liangshan Ethnic Yi Prefecture, and Panzhihua District, where about 4 million people belong to an ethnic minority (Liu and Lei, 1993; Ni, 1995; Li *et al*, 2003a). Results from a village-based survey in an ethnic Yi community of Xide County of Liangshan Prefecture in 1993, showed that 4.0% (62/1,542) of individuals reported a history of *Taenia* proglottid expulsion, 0.5% presented with subcutaneous nodules and 7.3% were seropositive for *T. solium* cysticercosis antibodies (Zhou *et al*, 1993). The most recent study conducted in a Tibetan population of Ganzi Prefecture indicated a very high prevalence of taeniasis (22.5%), and a significant occurrence of late-onset epilepsy (8.5% prevalence, 16.4% seropositive for *T. solium* antibodies) attributable in large part to probable neurocysticercosis caused by *T. solium* (Li *et al*, 2006). In this study, modern laboratory tests were applied, including multiplex PCR for *Taenia* species identification, a coproDNA test, and coproantigen detection by enzyme-linked immunosorbent assay (ELISA). In addition, a serological test (ELISA) using specific glycoproteins (GPs) or chimeric recombinant antigens, was used to screen for exposure to cysticercosis. The results of this study demonstrated the co-existence of all three species of human *Taenia* (*T. saginata*, *T. solium*, and *T. asiatica*) in a Tibetan population in China. The human beef tapeworm, *T. saginata* was however the dominant species causing human taeniasis in this population. A total of 30.5% of 661 persons reported proglottid expulsion (anamnesis) and 18/21 proglottids were confirmed by PCR as *T. saginata* and 3 as *T. asiatica*. In addition, 21.5% of persons were positive for *Taenia* coproantigens. Cysticerci from one local pig were also confirmed after DNA analysis as *T. solium*. A high prevalence of late-onset epilepsy (8.5%) was reported in local inhabitants, although the overall *T. solium* cysticercosis seroprevalence was 4.0%. A strong correlation was shown between the prevalence of epilepsy/convulsions in this community and

seropositivity against *T. solium* cysticercosis. That is, serology was positive in 16.4% of Tibetan subjects with epilepsy, compared to a 2.0 % seropositivity for populations without epilepsy. This suggests the possibility of neurocysticercosis (NCC). *T. solium* should therefore be considered as a potential emergent public health problem in Tibetan communities in this region of Sichuan.

A previous study conducted in Zhaojue County of Liangshan Prefecture (Sichuan) randomly sampled at postmortem 30 pigs from 5 townships of which 9 were found to be infected with cysticercosis (Fu *et al* 1998). Porcine cysticercosis has now been reported from all 17 counties of Liangshan Prefecture, with high endemicity centralized in ethnic Yi communities, where the prevalence in pigs ranged from 3.3% to 10.4% with the highest at 25-30% (Zhang *et al*, 2003). Based on the data recorded in the Liangshan prefectural abattoir, 291 (0.7%) out of 40,791 pigs slaughtered in 2001 were positive with cysticerci, compared to 0.5% (137/29,331) in the year 1990.

A recent national survey of parasitic diseases in China by the Ministry of Health, indicated an average taeniasis fecal prevalence of 0.28% (983/356,629), with the highest taeniasis prevalence (21%) in the Tibet Autonomous Region (Ministry of Health, China, 2005). Based on the study of Li *et al* (2006) cited above, we expect that most of this infection in Tibet AR was due to *T. saginata*.

Only 3 human cases of cysticercosis with autochthonous infections were reported from Guizhou Province in 1980, 1992, and 2002, respectively (Lin, 1980; Fu and Liu, 1992). However, a study of porcine cysticercosis performed in 9 districts of this province in the 1990s via postmortem inspection indicated an extensive distribution of this disease in the study area, with an average prevalence of 7.6% (328/4,292), with a highest infection rate of 12.1% recorded in those pigs raised by ethnic Yi (Table 4) (Qian *et al*, 1998). We can therefore suggest that human taeniasis/cysticercosis is probably also highly endemic in these regions. In addition, the occurrence of the species of *T. asiatica* was also confirmed in Guizhou Province by DNA genotyping (Wang and Bao, 2003).

Table 4
Infection of porcine cysticercosis in different Minority owners in Guizhou Province (postmortem inspection).

| Minority | Miao | Buyi | Yi | Zhuang | Hui | Shui | Dong | Gelao | Total |
|---------------|------|------|------|--------|-----|------|------|-------|-------|
| No. dissected | 798 | 973 | 314 | 567 | 694 | 305 | 473 | 168 | 4,292 |
| No. positive | 63 | 86 | 38 | 21 | 62 | 14 | 36 | 8 | 328 |
| % Infection | 7.9 | 8.8 | 12.1 | 3.7 | 8.9 | 4.6 | 7.6 | 4.8 | 7.6 |



Fig 1- Map of China with the locality of the capital (Beijing) and the locality of 5 highly endemic areas. 1: Sichuan Province; 2: Yunnan Province; 3: Guizhou Province; 4: Qinghai Province; 5: Inner Mongolia.

CONCLUSION

Currently, *Taenia solium* taeniasis and cysticercosis are highly endemic in China, primarily in Yunnan, Sichuan, and Guizhou in the southwest, and in Qinghai provinces and Inner Mongolia in the northwest and northern regions (Fig 1). Several risk factors appear to be important, including a common practice of consuming raw or undercooked pork, the use of free-ranging pigs, inadequate disposal of human feces, absence of meat inspection, poor hygiene, and low socio-economic levels. The national authorities as well as local health

services therefore need to give increased priority to *T. solium* taeniasis/cysticercosis control and prevention in high endemic regions of China. Active detection and treatment of *Taenia* carriers, and improved treatment of human and even swine cysticercosis should be considered. In addition, promotion of health education, sanitation, and enhancement of meat inspection also need to be improved in endemic regions. Application of specific serology for *T. solium* cysticercosis and coprotests for *Taenia* spp infection with high sensitivity/specificity (Ito *et al*, 2003) is needed to accelerate successful surveillance and control of this unique zoonotic disease in China.

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