CYSTICERCOSIS AND TAENIASIS IN THAILAND

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Abstract. Taeniasis is a common food-borne parasitic zoonosis in Thailand. Infection rates by stool examination vary, depending on the place and time of examination, and have been reported as 0.2-7.0%. Nationwide data indicate that most cases occur in the north and northeast (approximately 1.2%). By molecular analysis, *T. asiatica* infection was first discovered in Thailand in 25% (6/24) of taeniasis cases. The identifications were based on either multiplex PCR, base excision sequence scanning thymine-base (BESS T-base) analysis, and DNA sequencing of PCR products using *cytochrome coxidase* subunit 1 and *cytochrome b* genes. DNA sequencing showed that the *T. solium* in these patients were the Asian genotype. By molecular identification, a dual infection of *T. solium* and *T. asiatica* was first found in Thailand, which was also the first in Asia. The usefulness of molecular analysis for identifying human taeniid cestode infections is stressed. Cysticercosis, a potentially fatal chronic disease in humans, is caused by *C. cellulosae* developed in humans by ingestion of *T. solium* eggs. From 1947 to 2004, approximately 500 cases of human cysticercosis have been reported in Thailand, while the actual number of cases is speculated to be several times more.

INTRODUCTION

Human taeniasis is still common and a relatively serious public health problem worldwide. It is caused by either *Taenia saginata* (the beef tapeworm) or *Taenia solium* (the pig tapeworm) in the intestine. In Asia, a third of *Taenia* infections is caused by *Taenia asiatica* as has been reported in many countries (Ito *et al*, 2003, 2004). The larval stage of *T. saginata*, *Cysticercus bovis*, is found in the muscles of cattle; whereas *Cysticercus cellulosae* of *T. solium* and *Cysticercus viscerotropica* of *T. asiatica* (Eom and Rim, 1993; Eom, 2006) are found in the muscles and in the viscera, respectively, of pigs. Humans become infected with these *Taenia* species in the intestine by ingesting uncooked or poorly cooked beef, pork, or pork viscera that are contaminated with cysticerci. Eggs excreted into the environment from the adult worms of *T. solium* from tapeworm carriers can develop into *C. cellulosae*, which can cause cysticercosis, a fatal disease in humans as well as in pigs and even in dogs (Ito *et al*, 2003, 2004). Therefore, taeniasis solium is an important food-borne taeniid zoonosis in many developing countries, including Thailand.

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HUMAN CYSTICERCOSIS

Cysticercosis, caused by the *C. cellulosae* of *T. solium*, is expected to be one of the most potentially lethal helminthic infections in humans and an important public health problem worldwide. When eggs that are released from *T. solium* carriers are ingested by humans, pigs, or dogs, the hatched oncospheres develop into cysticerci in many tissues and organs and cause various types of cysticercosis. Neurocysticercosis of the central nervous system (CNS) is the most serious in humans because a single cysticercus or multiple cysticerci develop in the CNS, mostly in the brain (Ito *et al*, 2006; Takayanagui and Odashima, 2006). The most common symptom is epileptic seizure. Another relatively serious type is ophthalmic cysticercosis, which often causes a high degree of visual impairment. An asymptomatic type is subcutaneous or muscle cysticercosis. This review is based on reports of approximately 500 cysticercosis cases, mainly published in Thailand.

Distribution and sex

Most cases of cysticercosis were reported

in hospitals in Bangkok, especially in medical school hospitals without any record of patient domicile. Residential analyses of patients were found in two reports. In 25 patient records from Rajvithi Hospital in 1997, patients were mainly from the northern provinces (44%); the remainder were from the central (32%), northeastern (20%), and southern regions (4%) (Techathuvanan, 1997). Among 98 cases reported from Prasat Neurological Hospital, more cases were from the north (27.6%), Bangkok (25.5%) and the central region (25.5%), followed by the northeast (11.2%) and east (10.2%) (Jitsukon and Towanabut, 1989). There were more cases of cysticercosis reported from Hospitals in the northern provinces than the northeastern provinces (Menakanit, 1963; Tantajumroon and Thitasut, 1966; Chotmongkol, 1988, 2001). The existing residential data summarized in this review showed most cases (68 cases) were from the central region, including the eastern provinces and Bangkok, followed by the northern (58 cases) and northeastern regions (32 cases), and rarely from the south (2 cases). The disease is found more often in males than females, at a ratio of 1.9: 1 among about 400 reported cases

Neuro- and soft tissue-cysticercosis

Neurocysticercosis (NCC) in humans was first mentioned in Thailand in 1947 in a textbook for medical students at Siriraj Hospital. The first case was diagnosed in 1934 in an autopsied female, who resided in Tak Province, showing hundreds of *C. cellulosae* in the cerebral cortex. The second case was also an autopsied, a male from Ubon Ratchathani Province in 1939 with a large number of cysticerci in the grey matter of the brain (Daengsvang and Tansurat, 1947). Four males with epileptic convulsions were reported from the same hospital in 1954; many subcutaneous nodules were found in all these cases, and pathological examinations of sectioned nodules revealed cysticercosis (Viranuvatti and Toochinda, 1954). In 1962, four NCC cases confirmed by autopsy were reported (Chitanond and Indavasu, 1962). These early cases were from government hospitals in Bangkok Metropolis, and the diagnosis was mainly based on pathological biopsy specimens and post-mortem samples.

The introduction of computed tomography (CT) and magnetic resonance imaging (MRI) has increased the number of diagnosed cysticercosis patients in the country. Between 1979-1988 and 1981-1986, 98 and 132 cases, respectively, were diagnosed as NCC at Prasat Neurological and Siriraj Hospitals (Bhoopat *et al*, 1989; Jitsukon and Towanabut, 1989). A five-year retrospective study of 25 cases in Rajvithi Hospital during 1993-1997 showed that 60% (n = 15) in CNS, 24% (n = 6) in soft tissues, and 16% (n = 4) in the eye (Techathuvanan, 1997).

Soft-tissue cysticercosis (STCC) involves nodules in subcutaneous tissues (subcutaneous cysticercosis, SCC) and muscle. As STCC does not in general cause serious manifestations, STCC cases have not been frequently reported. Diagnosis was based on pathological examination of surgical specimens. Daengsvang and Tansurat (1947) recorded the first three cases having subcutaneous nodules at Siriraj Hospital. A number of cases of STCC co-existed with NCC cases. Seven out of eight neurologically symptomatic patients admitted to the Neurological Section at Phramongkutklao Hospital were confirmed to have subcutaneous nodules (Punyadassaniya, 1972). The same author conducted a retrospective study of patient records from the Pathology Section: 70 SCC cases (48 males, 22 females) were recorded during 1955-1972. Chitchang (1966) reported 20 SCC patients (18 males and 2 females, aged 13-54 years) in 1961-1965. The sites commonly affected were the extremities. Neurologic symptoms were demonstrated in 5 of these 20 SCC cases. SCC cases from the two above reports were from the same source; thus, the number of cases might overlap. CT-based diagnosis of 132 NCC cases at Siriraj Hospital showed that 13 patients had subcutaneous nodules or characteristic muscular calcification (Bhoopat *et al*, 1989). Similarly, the in-patient hospital records at Prasat Neurological Hospital showed that 5% of 98 NCC cases had subcutaneous nodules. It was interesting that 23% and 58% of the cases showed X-ray calcification on thigh and chest, respectively (Jitsukon and Towanabut, 1989).

At Chiang Mai University Hospital in the north in 1962-1966, 13 cases of cysticercosis

were found by pathology: 10 were STCC and 3 others were NCC (one patient had subcutaneous nodules over the entire body). Cysticercus was confirmed by biopsy of a 1-cm nodule (Tantajumroon and Thitasut, 1966). At Khon Kaen University Hospital in the northeast, 2 of 12 NCC cases showed soft tissue cyst calcification (Chotmongkol, 1988).

From 1947 to 2000, approximately 300 cases of NCC and 100 cases of STCC were recorded. The reports of STCC cases that appear in the literature might be lower than the actual situation. Patients with subcutaneous nodules might not be concerned about themselves, and the physicians might misdiagnose the nodules as sebaceous cysts, lymphadenitis, tumors, or other skin lesions (Chitchang, 1966).

Racemose cysticercosis

Abnormal growth of *Cysticercus* appears as multiple cysts attached to the central stem by stalks, like a bunch of grapes, producing racemose cysticercosis. The cystic larva, *Cysticercus racemosus*, contains no scolex. The first recorded case, a 36-year-old male from Kamphaeng Phet, a northern province, was observed to have a sparganum-like object involving the base of the brain and spinal subarachnoid space in 1969 (Pradatsundarasar, 1980). In 1971, a cyst-like parasite object was found in the subarachnoid space of the brain of a female Bangkok resident and was diagnosed as a sparganum-like tapeworm (Pradatsundarasar *et al*, 1971). Histological sections of these two cases were later re-identified as *C. racemosus* (Pradatsundarasar, 1980; Chayapum *et al*, 1993). Two more cases were reported in 1980 in the ventricles of the brain of Thai males (Patharangkura *et al*, 1980). In the south of Thailand where taeniasis was rarely found, racemose cysticercosis in the basal subarachnoid space of the brain and the thoracic subarachnoid space was reported in a male from Yala Province (Chayapum *et al*, 1993). Recently, racemose NCC in the subarachnoid space at the cistern of the brain through the lumbar cistern was found in a patient from Phitsanulok, a northern province. The patient presented with paraparesis and bilateral hearing loss (Jarupant *et al*, 2004). The disease caused by *C. racemosus* is quite severe and potentially fatal, because relapse occurs frequently. Until 2004, 6 cases were reported as racemose cysticercosis in Thailand.

Ocular cysticercosis

Ocular cysticercosis (OCC) has been reported occasionally, compared with NCC and STCC. In 1956, almost 10 years after the first record of cysticercosis in Thailand, OCC cases in 2 females who presented with painful and dimmed visual acuity were first reported in the literature (Kanjanarun, 1956a,b). In Chiang Mai, a 20-year-old male had a cyst-like mass in the posterior chamber of the eye (Khamboonruang and Mahasuwan, 1971). In 1997, 1 case of cysticercosis in the vitreous and 3 cases of subretinal cysticercosis were diagnosed from 25 cysticercosis cases admitted at Rajvithi Hospital (Techathuvanan, 1997). A live cyst and a 9.0 mm cyst were successfully removed from the subretina of a 25- and a 36-year-old male, respectively, from northeast Thailand (Kittiponghansa *et al*, 1988; Lerdvitayasakul and Lawtiantong, 1991). Until 1997, approximately 10 OCC cases were reported in the literature.

Cysticercosis of other organs

Cysticercosis was also reported in other organs of the body. An autopsy of a 65-year-old male conducted at Siriraj Hospital in 1947 revealed a 0.5 cm cyst at the myocardium of the left ventricle. The patient had no particular heart symptom (Daengsvang and Tansurat, 1947). An autopsy of a 40-year-old male who had died of NCC showed several cysts in the heart and lungs. The cyst was confirmed as *C. cellulosae* by pathological examination (Saengsingkaeo and Bunnag, 1965). Two cysticerci were found in the thyroid gland of a 28-year-old female who died of heavy NCC with >1,500 cysts in the brain (Leelachaikul and Chuahirun, 1977).

Cysticercosis co-existing with taeniasis

Cysticercosis co-existing with taeniasis is not really uncommon. Chotmongkol (1992) reported that stool examinations of three NCC patients revealed one with *Taenia* eggs. Four percent of 98 NCC cases registered at Prasat Neurological Hospital had proglottids in the stool (Jitsukon

and Towanabut, 1989). Of 25 cysticercosis cases diagnosed at Rajvithi Hospital, one patient had a history of expulsion of *Taenia* proglottids in the feces, while another had *Taenia* eggs in the feces (Techathuvanan, 1997).

TAENIASIS

Taeniasis is a common food-borne parasitic zoonosis in Thailand. The disease is known to be caused by the two species, *T. saginata* and *T. solium*.

Prevalence and distribution

In the north and northeast of Thailand, people customarily consume raw or undercooked meat; therefore, taeniasis is relatively common among the residents there. Reported occurrences were generally based on findings of eggs in stool specimens. The latest nationwide stool survey, conducted in 2001 by the Ministry of Public Health with 17,025 residents of any age, showed the highest *Taenia* infection rate was 1.25% in the north, followed by 1.17% in northeast (Ministry of Public Health, 2001). In an early nationwide survey in 1957, the infection was highest in the northeast, with 3.4% prevalence (Vajrasthira and Harinasuta, 1957). Several nationwide surveys later showed infection was higher in the north and northeast, between 1-2%, and lower in the central region (<1%), and rare in the south (Table 1) (Vajrasthira and Harinasuta, 1957; Preusaraj *et al*, 1982; Jongsuksantigul *et al*, 1992; Jiradit *et al*, 1997; Ministry of Public Health, 2001).

Individual reports in some locations showed variable prevalence. A high prevalence (5.9%) was found among 1,450 hilltribe people residing in 6 upper northern provinces (Mae Hong Son, Chiang Mai, Chiang Rai, Lampang, Lamphun, Phayao), and 1.9% prevalence among 2,540 hilltribe people along the Thai-Lao PDR border of Nan Province (Wijit and Kraewsan, 2001; Maipanich *et al*, 2004). In the northeast, the infection rate was 7.0% among 438 stool samples from Udon Thani Province, in 1967 (Chularerk *et al*, 1967). Two decades later, in 1987, it was still high, at 5.9% among 202 residents of Kalasin (Ektaseng *et al*, 1987). In a survey in 1996, the prevalence rate was 3.3% in 5,125 residents from 7 provinces of the region (Nakhon Phanom, Maha Sarakham, Yasothon, Roi Et, Ubon Ratchathani, Loei, and Chaiyaphum), (Sithithaworn, unpublished data). The prevalence was rather low in Khon Kaen Province, at 0.2% in 395 stool samples from villagers (Rhongbutsri and Kitvatanachai, 2002).

Table 1
Chronological nationwide prevalence (%) of *Taenia* infection, by regions, Thailand.

Regions	Years				
	1957[a]	1982[b]	1992[c]	1997[d]	2001[e]
North	1.2	0.94	2.33	1.8	1.25
	(99/8,389)	(80/8,485)	(284/12,146)		(48/3,841)
Northeast	3.4	1.13	1.17	1.5	1.17
	(6,531/192,499)	(165/14,582)	(149/12,705)		(50/4,287)
Central	0.2	0.66	0.23	0.2	0.16
	(45/21,478)	(89/3,548)	(33/13,924)		(9/5,613)
South	0	0.06	0	0	0
	(0/41,337)	(4/6,724)	(0/6,388)		(0/3,284)
Total	2.5	0.78	1.03	0.9	0.63
	(6675/263,703)	(338/43,339)	(466/45,163)		(107/17,025)

Number in parenthesis are No. positive/Total

[a]Vajrasthira and Harinasuta, 1957; [b]Preuksaraj *et al*, 1982; [c]Jongsuksantikul *et al*, 1992; [d]Jiradit *et al*, 1997; [e]Ministry of Public Health, 2001.

In the central region, infection rates were relatively low if compared with the north and northeast. In the west-central, along the Thai-Myanmar border, a prevalence of 2.8% was found among 286 Thai troops working in Ratchaburi (Maneeboonyang *et al*, 2004) and 0.7% among 761 residents of Kanchanaburi (Anantaphruti *et al*, 2004). In and around Bangkok Metropolis, of 189 adults, 25% were positive for intestinal parasitoses, and 2% of these were infected with *Taenia* sp (Pitisuttithum *et al*, 1990).

Higher prevalence figures were shown in an investigation of worm purging following drug administration; 102 (14.9%) taeniasis cases were found among 681 residents who received praziquantel in 16 northeastern provinces. The infection rate was higher in males than in females (Radomyos *et al*, 1994). A similar investigation was performed in 16 northern provinces, where 21 (4.9%) of 431 residents were infected with *Taenia* sp (Radomyos *et al*, 1998).

About 40-50 taeniasis cases are admitted to the Outpatient Clinic of the Hospital for Tropical Diseases, Faculty of Tropical Medicine, Bangkok each year (Hospital for Tropical Diseases, 2002, 2003, 2005). This figure was similar to previous records for the period 1977-1978, where 39 patients who discharged segments of *Taenia* sp attended the same Hospital (Charoenlarp *et al*, 1981).

Taenia species

T. saginata infection was more common than *T. solium*. The scolices evacuated by 34 patients and the proglottids expelled from another 23 patients were all identified as *T. saginata* (Manmontri, 1949; Chularerk *et al*, 1967; Charoenlarp *et al*, 1989). *T. solium* was found in 3/35 *Taenia*-infected patients; whereas, all others were identified as *T. saginata* by the morphological characteristics of the scolex, except 2 cases with proglottids without scolex (Chirasiri, 1963; Charoenlarp *et al*, 1981). Molecular analysis of 37 samples of proglottids from taeniasis patients in Chiang Mai showed that they all were *T. saginata* (Bowles and McManus, 1994; Morakote *et al*, 2000). *T. solium* infection seems to be rare in Thailand, but cysticercosis cases were quite often reported, as mentioned above. Anantaphruti *et al* (2007) reported a high prevalence of *T. solium* infection in a remote area in Kanchanaburi, a west-central province. Sixteen persons of 24 taeniasis episodes expelled scolices with or without proglottids. Based on morphological characteristics of the scolex, 31% (5/16) of cases were confirmed to be *T. solium*. Consequently, the expelled proglottids/scolex from these patients were also identified as *T. solium* Asian genotype based on molecular analysis by either BESS-T analysis (base excision sequence scanning thymine-base), multiplex PCR, or DNA sequencing (methods described by Yamasaki *et al*, 2002, 2004, 2006). Eleven cases of *T. solium* infection from 24 taeniasis patients (46%) were found in this study area. Moreover, by these molecular identification methods, it was the first evidence of *T. asiatica* from Thailand; both *T. asiatica* and *T. saginata* are sympatrically occurring in 6 and 7 patients, respectively (Anantaphruti *et al*, 2007).

Worm burden and mixed infection

Each taeniasis patient generally harbored only one *Taenia* sp worm. Among the scolices expelled from 58 *T. saginata* cases, the maximum number of scolices was 3 in 1 patient and 2 in 10 patients. The remaining 47 patients harbored a single scolex each (Viranuwatti, 1952; Chirasiri, 1963; Charoenlarp *et al*, 1981, 1989). Based on the proglottids evacuated, Chaneyayothin (1971) reported 5 *T. saginata* worms expelled from one patient after treatment with a Thai herbal drug. Unfortunately, no scolices were expelled for numbering confirmation. More worms were recorded in *T. solium* infections. The maximum number of scolices found was 6 in one patient. Three scolices were found from 3/5 cases who purged scolices (Anantaphruti *et al*, 2007).

Mixed infections of two species of *Taenia* have been reported. Chirasiri (1963) reported that a patient evacuated a scolex of *T. solium* together with proglottids identified as *T. saginata*. Unfortunately, no scolex was found for specific confirmation of *T. saginata* in this case. In 2002, two scolices of *T. solium* together with one scolex of *T. saginata* were expelled from a patient in Kanchanaburi Province. The worms were identified as *T. solium* Asian genotype and *T. asiatica* confirmed by molecular

analysis. This dual infection of *T. solium* and *T. asiatica* was the first case found in Asia. It concluded that molecular analysis is highly useful for identification of human taeniid cestodes (Anantaphruti *et al*, 2007).

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