

THE PRESENT SITUATION OF TAENIASIS AND CYSTICERCOSIS IN ASIA AND THE PACIFIC

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Abstract. *Taenia solium* cysticercosis is briefly overviewed. Atypical neurocysticercosis cases that lack specific information from clinical manifestation, neuroimaging, serology, or histopathologic examination require molecular identification of histopathologic specimens for obtaining of concrete evidence of infection with metacestodes of *T. solium*. The present situation of taeniasis and cysticercosis in Asia and the Pacific is overviewed based on our joint projects in Indonesia, China, and Thailand. Both *T. saginata* from beef and *T. asiatica* from the viscera of pigs occur sympatrically in China and in Thailand; whereas, such a sympatric occurrence is not confirmed in Indonesia, where the religious taboo about food is quite strict.

INTRODUCTION

Taeniasis in Asia and the Pacific has a unique spectrum because three species (*Taenia solium*, *T. saginata*, and *T. asiatica*) have been reported in this area (Ito *et al*, 2003a, 2004). Regarding the third species, *T. asiatica*, it remains debatable whether it is an independent species. Study that is more detailed would be necessary on mitochondrial and nuclear DNA in co-endemic areas in Asia and the Pacific before any conclusion could be made (Okamoto *et al*, unpublished data). Cysticercosis is known only from *T. solium*, although *T. asiatica* requires pigs as the intermediate host, which is similar to *T. solium* (Ito, 1992; Ito *et al*, 2003a). Recent molecular evidence strongly suggests that *T. asiatica* is very close to *T. saginata* and is a sister-species of *T. saginata* and has a far distance from *T. solium* (Hoberg *et al*, 2000, 2001; Hoberg, 2006; Nakao *et al*, 2002; Eom, 2006). Based on molecular and morphological studies (Eom, 2006), it is predicted that cysticercosis in humans, attributable to *T. asiatica*, does not occur because

cysticercosis is unknown as its sister species, *T. saginata* (Ito *et al*, 2003a). There is no doubt that there are hot spots of taeniasis and cysticercosis in Asia and the Pacific (Ito *et al*, 2003a).

TAENIA SOLIUM CYSTICERCOSIS

Taenia solium cysticercosis is one of the most potentially lethal parasitic diseases worldwide. The main cause of late-onset epilepsy in developing countries that are endemic areas for *T. solium* is expected to be due to a cysticercus or cysticerci of *T. solium* (Ito *et al*, 2006a; Takayanagui and Odashima, 2006). The importance of clinical manifestation, neuroimaging, serology, and molecular confirmation of neurocysticercosis (NCC) has been briefly overviewed (Ito *et al*, 2006a). It is known that approximately 10% of NCC cases may show typical imaging figures, and almost all active NCC cases with multiple cysts in the brain show specific antibodies to the specific antigens, either native glycoproteins or recombinant proteins (Tsang *et al*, 1989; Ito *et al*, 1998; Chung *et al*, 1999; Sako *et al*, 2000, 2006; Hancock *et al*, 2003; Sato *et al*, 2003, 2006). Therefore, with patients who have a history of residence or visiting endemic areas of NCC, we have to be reminded of NCC. Serology to detect specific antibodies using highly specific antigens, either produced at CDC, USA, or Asahikawa

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Medical College, Japan, is highly useful before surgery (reviewed by Ito *et al.* 2006a). However, if NCC cases with a solitary cyst, or even with multiple cysts, show only atypical imaging figures and no specific antibody response, we would have no critical identification of such cases. No clinical manifestation of NCC is specific or unique to NCC. Therefore, we have to consider some other diseases caused by other parasitic, bacterial, or viral infections, and malignant tumors as well as NCC. In the case of racemose form of NCC showing hydrocephalus in non-endemic areas, we rather consider toxoplasmosis, tuberculosis, and malignant brain tumors, etc. The difficulty in a confirmative diagnosis of NCC or other diseases in the brain is the lack of necropsy cases, especially in endemic developing countries. However, in some relatively rare cases, histopathological specimens may be available after brain surgery.

Histopathological examination of resected lesions often reveals the hooklets as well as the suckers and the unique morphological structures of cestodes. So far as we know, we usually conclude that such cases are metacestodes of *T. solium*. However, is it really sound without molecular confirmation? There is no real concrete evidence on the speciation if they have no hooklets. It might be due to technical loss of such structure through processing, or it might be due to some other taeniid metacestodes that rarely infect humans or are underestimated without molecular identification. Therefore, it is essential for us to identify the species based on molecular evidence. Such topics have just been overviewed (Yamasaki *et al.*, 2005; Ito *et al.*, 2006a,b).

THE PRESENT SITUATION OF TAENIASIS AND CYSTICERCOSIS IN ASIA AND THE PACIFIC

A long-standing puzzle has been that adult taeniid tapeworms expelled from people in Asia-Pacific seem to be *T. saginata*, the beef tapeworm, although these people eat pork rather than beef (Yokogawa, 1935; Hsieh, 1960; Huang *et al.*, 1966; Ito *et al.*, 2003a). This is now generally considered to be due to the third species, *T. asiatica* (Fan, 1988; Fan *et al.*, 1995; Eom and

Rim, 1993; Simanjuntak *et al.*, 1997; Hoberg *et al.* 2000, 2001; Hoberg, 2006; Eom, 2006). *T. asiatica* has been reported from Taiwan, China, South Korea, Indonesia, Philippines, and Vietnam where local people eat pork rather than beef (Ito *et al.*, 2003a, 2004). Therefore, it is now clear that some areas where we had identified *T. solium* and *T. saginata* are rather due to *T. solium* and *T. asiatica*, or due to *T. solium* and *T. asiatica* and *T. saginata*. It is necessary for us to re-examine the historical specimens identified to be *T. saginata* in Asia and the Pacific (Ito *et al.*, 2003a).

Present situation in Indonesia

The majority of Indonesian people is Muslim. Therefore, *T. solium* and *T. asiatica* that are caused by ingestion of raw or under cooked pork and viscera are expected to be absent. However, in some areas or islands, where the majority is Hindu, such as in Bali, or Christians in Papua (formerly Irian Jaya) or North Sumatra, *T. solium* or *T. asiatica* are common. So far as we know, *T. solium* taeniasis/cysticercosis is recognized in Papua, but there is no other taeniid species (Simanjuntak *et al.*, 1997; Wandra *et al.*, 2003; Margono *et al.*, 2006). In North Sumatra, *T. asiatica* is rather more common than *T. solium*. So far as we have examined, there is no *T. solium* case in Samosir Island in Lake Toba, North Sumatra (Wandra *et al.*, unpublished data). In Bali, *T. solium* cysticercosis has been known to be endemic. However, it is currently rare (Sudewi *et al.*, in press). Rather, *T. saginata* due to consumption of raw beef (beef *lawar*) is becoming much more common, because Balinese can eat beef, even if they are Hindu. In Bali, there is no *T. asiatica* case at all. It is expected to be due to the local eating customs. They eat uncooked minced pork with blood or beef (pork *lawar* or beef *lawar*) but do not eat uncooked viscera of pigs. This is a crucial difference between Balinese and Batak people in North Sumatra who like uncooked viscera of pigs. In North Sumatra, *T. asiatica* is common due to the consumption of uncooked or undercooked viscera of pork (*sang sang*). Therefore, there is no area in Indonesia where we can expect sympatric occurrence of the three taeniid species. It is mainly due to the barrier of the religion and differences in taste for

raw or undercooked viscera, as shown in Bali and North Sumatra (Wandra *et al*, 2006a,b).

Present situation in China

T. solium cysticercosis is one of the most common parasitic diseases in China (Ito *et al*, 2003b) because the favorite cuisine in China is pork. Both *T. solium* and *T. saginata* have commonly been reported in China (Chen *et al*, 2005). However, there are few reports demonstrating *T. asiatica* in China (Eom *et al*, 2002; Yamasaki *et al*, 2004). Most recent work in the Tibetan population in Sichuan, China has suggested that the three species are sympatrically distributed there (Li *et al*, 2006). Local people eat raw or uncooked minced pork and viscera. It is expected to be the basic risk factor for both *T. solium* and *T. asiatica*. We have to re-examine "*T. saginata*," where both *T. solium* and *T. saginata* have been reported (Eom *et al*, 2002; Yamasaki *et al*, 2004). An up-dated overview of taeniasis/cysticercosis in China is presented at the 5th FBPZ meeting in Bangkok (Li *et al* 2007).

Present situation in Thailand

So far as we know, there is no evidence of the occurrence of *T. asiatica* in Thailand (Bowles and McManus, 1994; Morakote *et al*, 2000). All specimens examined for mitochondrial DNA were confirmed to be *T. saginata*. The most recent work in Kanchanaburi, western part of Thailand, *Taenia* specimens from 24 patients were collected. They were identified morphologically to be *T. solium* and *T. saginata*. Later, the "*T. saginata*" were confirmed to be *T. saginata* (n = 7) and *T. asiatica* (n = 6) by mitochondrial DNA analysis in Asahikawa. Among these, one patient expelled three worms. Two had scoleces with armed hooklets and were expected to be *T. solium*, and the remainder had no hooklets and was expected to be "*T. saginata*." With mitochondrial DNA analysis of scoleces on glass slides, using T base-pair excision test (Yamasaki *et al*, 2004), "*T. saginata*" was confirmed not to be *T. saginata* but rather *T. asiatica*. It was the first dual infection case of *T. solium* and *T. asiatica* confirmed by molecular tools (Anantaphruti *et al*, 2007).

Present situation in other countries in Asia and the Pacific

Through the special fund from the Ministry of Education, Japan to A Ito (2003-2005), we organized 4 technical transfer seminars during the three-year period. A total of 40 researchers from 14 countries were invited to attend the seminars with full financial travel support from this special fund (Ito *et al*, 2006b). We invited others from the Philippines, Vietnam, Lao PDR, Nepal, and Mongolia in Asia, as well as from China, Indonesia, and Thailand, as summarized above, and from other countries in Asia. So far as we know, we could have confirmed *T. asiatica* and *T. solium* from the Philippines, whereas *T. saginata* and *T. solium* were confirmed from Vietnam, Lao PDR, and Nepal (Yamasaki *et al*, unpublished data). Only *T. saginata* has been confirmed in Mongolia (Myadagsuren *et al*, 2007). It is known that *T. asiatica* is distributed in Vietnam (Le *et al*, 2003). In these countries, and in China, Thailand, and Indonesia further systematic survey should be carried out for getting detailed information on the three species and background information on the life cycles.

PERSPECTIVES

Historically, there have been few cases of dual infection with *T. solium* and *T. saginata*. Such dual infection may occur but, if such cases were recorded from Asia and the Pacific, we would expect it to be due to *T. solium* and *T. asiatica* through eating raw or uncooked minced pork with viscera, which is still rather common in China, Vietnam, northern part of Thailand, and perhaps in Myanmar and some other countries. Such historical specimens of *T. saginata* may be re-examined (Ito *et al*, 2003a; Yamasaki *et al*, 2006; Anantaphruti *et al*, 2007).

There are many strategies that have been launched for the control of taeniasis/cysticercosis in humans and pigs. So far as we know, although there is no active strategy such as vaccination of pigs for control of *T. solium* cysticercosis or treatment of taeniasis solium other than sustainable education and recommendation of no free access of pigs to human feces by keeping pigs indoors and by the use of ratlines, it appears

to be true that *T. solium* cysticercosis has been eradicated or has become rare in Europe, Japan, Korea, and Bali in Indonesia. Therefore, sanitary disposal of human feces is expected to prevent infection of pigs and is the essential procedure in the control of taeniasis solium (Schantz *et al*, 1993a; Pawlowski, 2006).

CONCLUSION

Taeniasis is one of the meat- or food-borne parasitic zoonoses common in Asia and the Pacific. It is caused by eating raw or uncooked minced pork and viscera, and beef. Through eating minced pork and viscera, both *T. solium* and *T. asiatica* are expected to be more common everywhere that local people love to eat in Asia and the Pacific. Among the three human *Taenia* species, *T. solium* is the most important as a public health issue because it causes neurocysticercosis as well. The distribution of these *Taenia* species may still be controlled in general by the taboos of religions. However, unexpected outbreaks of cysticercosis may be introduced, even in Muslim or Jewish societies, through immigrants or visitors who are asymptomatic taeniasis carriers (Schantz *et al*, 1993b; Hira *et al*, 2004). Cut-off of the life cycle of these tapeworm infections should be carried out on both human and animal sides. Sustainable education of people in endemic areas and the challenge for the production of safe meat are urgent tasks.

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