Current Status and Perspectives of Cysticercosis and Taeniasis in Japan

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Abstract: This mini-review describes recent epidemiological trends in cysticercosis and taeniasis in Japan. Some of the topics discussed herein were presented at the first symposium on “Current perspectives of Taenia asiatica researches”, that was held in Osong in Chungbuk Province, South Korea, in October 2011 and organized by Prof. K. S. Eom, Chungbuk National University School of Medicine. To better understand the trends in the occurrence of cysticercosis and taeniasis in Japan, clinical cases reported in 2005 have been updated. In addition, the current status of Taenia asiatica infections successively occurring in Japan since 2010 is also discussed.

Key words: Taenia solium, Taenia asiatica, Taenia saginata, taeniasis, cysticercosis, Japan

INTRODUCTION

Cysticercosis, a parasitic disease caused by Taenia solium cysticercus, is one of the important parasitic diseases. Neurocysticercosis (NCC) is accepted to refer to cysts in the central nerve system, including the parenchyma and ventricles of the brain and the spinal cord. Subcutaneous cysticercosis (SCC) is used for the cysticercosis presenting the form of firm, mobile nodules, mainly in the soft tissues and muscles of the trunk and extremities. NCC is clinically more serious than SCC because of the severity of the neurologic symptoms, such as epileptic seizures and paralysis that can result from infection. The disease constitutes a major public health problem in many parts of the world, including China, Southeast Asia, India, sub-Saharan Africa, and Latin America [1]. Cysticercosis has also become an important parasitic disease in developed countries, such as the United States, particularly in California and other states with a large immigrant population [2]. In Japan, although T. solium cysticercosis/taeniasis was endemic to the Okinawa region in southern Japan 50-60 years ago [3,4], the disease is no longer endemic in the area. Nonetheless, sporadic cases of cysticercosis have been reported in Japan, primarily among Japanese returning from abroad and foreigners coming to Japan (Table 1) [5].

Conversely, taeniasis, which is caused by infection with the adult tapeworm of T. solium or Taenia saginata, occurs worldwide, except in countries where people do not eat pork and beef for religious reasons [1]. Taeniasis caused by Taenia asiatica is restricted to countries in Asia, including South Korea, China, Taiwan, the Philippines, Vietnam, Thailand, Indonesia, and Japan [6]. In Japan, sporadic cases of taeniasis have been reported and most of them were caused by infection with T. saginata and were imported cases until T. asiatica infections were confirmed in 2010 (Table 2). Compared to cysticercosis, taeniasis is innocuous or asymptomatic, with most patients presenting with slight intestinal illness and mental discomfort due to persistent expulsion of the proglottids.

In Japan, the “Ordinance for Enforcement of the Food Sanitation Act” based on the Food Sanitation Law stipulates that food-borne parasitic diseases such as cysticercosis and taeniasis be treated as cases of food poisoning and that authorities be notified of their occurrence immediately. However, because parasitic diseases have never reported based on the law, it is not possible to accurately estimate the incidence of cysticercosis/taeniasis in Japan. Therefore, the author previously examined the epidemiological trends in cysticercosis and taeniasis based on clinical cases in Japan published in scientific journals [5]. Since then, new cases of cysticercosis and taeniasis have been reported and several cases of cysticercosis have been newly diagnosed in our department. The Department of Parasitol-
Table 1. Demographic and clinical data for cysticercosis cases reported in Japan (1990-2011)

| Case No. | Year | Patient (Nationality/Age/Sex) | Type of cysticercosis | Diagnostic criteria | Presumed locality of infection | References |
|----------|------|-------------------------------|-----------------------|---------------------|--------------------------------|------------|
| 1        | 1990 | Japanese/40/F (multiple)     | NCC (multiple)        | CT/Pathology        | Japan (Tokunoshima, Kagoshima) | 55         |
| 2        | 1991 | Korean/73/M (multiple)       | NCC (multiple)        | CT/MRI/Pathology    | Korea                           | 86         |
| 3        | 1991 | Japanese/33/M (solitary)     | NCC (solitary)        | CT/MRI/Serology     | Honduras                        | 87         |
| 4        | 1991 | Japanese/29/F (solitary)     | SCC (solitary)        | Pathology/Serology  | Thailand                        | 41         |
| 5        | 1991 | Japanese/48/M (solitary)     | Intraduodenal spinal (solitary) | CT/MRI/Pathology | Thailand                        | 44         |
| 6        | 1992 | Chinese/20/M (multiple)      | NCC (multiple)        | CT/MRI/Pathology    | China (Heilongjiang province)   | 88         |
| 7        | 1992 | Japanese/41/F (multiple)     | NCC (multiple)        | CT/MRI/Serology/Pathology | Hong Kong, Korea or Japan | 89         |
| 8        | 1992 | Japanese/30/M (multiple, racemose-type) | NCC (multiple) | CT/MRI/Pathology    | Japan (Sinoian, Okinawa)        | 50, 51     |
| 9        | 1992 | Korean/42/M (multiple)       | NCC (multiple)        | CT/MRI/Serology     | Korea                           | 90         |
| 10       | 1993 | Japanese/44/F (solitary)     | NCC (solitary)        | CT/Pathology        | Japan                           | 56         |
| 11       | 1993 | Japanese/46/M (solitary)     | Ocular (solitary)     | Funduscope/Pathology| Vietnam or Cambodia             | 45         |
| 12       | 1993 | Japanese/41/F (solitary)     | NCC (solitary)        | CT/MRI/Pathology    | Japan                           | 57         |
| 13       | 1993 | Brazilian/26/F (multiple)    | NCC (multiple)        | CT/Pathology        | Brazil                          | 91         |
| 14       | 1993 | Japanese/49/F (multiple)     | NCC (multiple, racemose-type?) | CT/MRI/Pathology | Japan                           | 52         |
| 15       | 1993 | Japanese/53/M (multiple)     | NCC (multiple, racemose-type?) | CT/MRI/Pathology | Taiwan                          | 55         |
| 16       | 1994 | Korean/48/M (solitary)       | NCC (multiple and SCC (systemic)) | CT/MRI/X ray/Pathology | Korea                           | 42         |
| 17       | 1994 | Japanese/43/F (multiple)     | NCC (multiple and SCC (systemic)) | CT/MRI/X ray/Pathology | Korea                           | 42         |
| 18       | 1994 | Japanese/72/F (multiple)     | NCC (racemose-type)   | CT/MRI/Serology/Pathology | China                           | 53         |
| 19       | 1994 | Japanese/24/M (multiple)     | NCC (racemose-type)   | CT/MRI/Pathology    | China                           | 54         |
| 20       | 1994 | Japanese/44/M (solitary)     | NCC (solitary)        | CT/MRI/Pathology    | Japan                           | 54         |
| 21       | 1994 | Japanese/52/F (solitary)     | NCC (solitary)        | CT/MRI/Serology     | Japan                           | 58         |
| 22       | 1995 | Japanese/21/F (multiple)     | NCC (multiple)        | MRI/PET             | Japan                           | 59         |
| 23       | 1996 | Japanese/39/M (solitary)     | NCC (solitary)        | MRI/Pathology       | Japan                           | 60         |
| 24       | 1996 | Japanese/39/M (solitary)     | SCC (solitary)        | Pathology           | China                           | 43         |
| 25       | 1996 | Japanese/49/F (multiple)     | NCC (multiple)        | CT/MRI/Serology/Pathology | China                           | 93         |
| 26       | 1997 | Chinese/68/M (multiple)      | NCC (multiple and SCC (multiple)) | CT/MRI/X ray/Pathology | China (Heilongjiang province) | 7          |
| 27       | 1998 | Chinese/48/M (multiple)      | NCC (multiple)        | CT/MRI             | China                           | 8          |
| 28       | 1998 | Japanese/37/M (multiple)     | SCC (solitary)        | Pathology           | Japan                           | 9          |
| 29       | 1998 | Japanese/34/M (multiple)     | NCC (multiple, SCC (multiple) and taeniasis)| CT/MRI/Serology | China (Jiujiang, Jiangxi Province) | 10         |
| 30       | 1998 | Japanese/59/M (multiple)     | NCC (multiple)        | CT/Pathology        | China                           | 11         |
| 31       | 1998 | Japanese/19/F (solitary)     | NCC (solitary)        | MRI/Pathology       | India                           | 12         |
| 32       | 1998 | Korean/55/M (multiple)       | NCC (multiple)        | CT/MRI/Endoscopy/Pathology | China                           | 13         |
| 33       | 1998 | Japanese/46/M (multiple)     | NCC (solitary)        | CT/MRI/Pathology    | Indonesia, Nigeria, or Nepal    | 14, 15     |
| 34       | 2000 | Japanese/45/F (multiple)     | SCC (multiple)        | CT/Pathology        | Thailand                        | 16         |
| 35       | 2000 | Cambodian/20/M (multiple)    | NCC (multiple and SCC (multiple)) | CT/MRI/X ray/Pathology | Cambodia                        | 17         |
| 36       | 2001 | Japanese/53/F (multiple)     | SCC (multiple)        | CT/Pathology        | No information                  | 18         |
| 37       | 2001 | Japanese/43/F (solitary)     | SCC (solitary)        | MRI/Pathology       | Thailand                        | 19         |
| 38       | 2001 | Unknown/73/M (multiple)      | SCC (solitary)        | MRI/Pathology       | No information                  | 20         |
| 39       | 2001 | Japanese/70/M (multiple)     | NCC (racemose type)   | CT/MRI/Serology     | Philippines                     | 21         |
| 40       | 2002 | Japanese/26/M (multiple)     | NCC (solitary)        | CT/MRI/Pathology/Serology | Japan                           | 22         |
| 41       | 2003 | Japanese/22/F (solitary)     | SCC (multiple)        | CT/MRI/Pathology/DNA | India                           | 23         |
| 42       | 2004 | Japanese/53/F (multiple)     | NCC (solitary)        | CT/MRI/Pathology/DNA | India, Vietnam, Thailand or Myanmar | 24, 25 |
| 43       | 2004 | Chinese/50/M (multiple)      | Ocular (solitary)     | Funduscop/CT/Serology/Pathology | China (Heilongjiang province) | 26         |
| 44       | 2004 | Japanese/33/M (multiple)     | SCC (systemic)        | CT/X ray/Pathology/DNA | China                           | 27, 28     |
| 45       | 2005 | Chinese/44/F (multiple)      | SCC (multiple)        | CT/MRI/X ray        | China                           | 29         |
| 46       | 2005 | Chinese/21/F (multiple)      | SCC (multiple)        | CT/MRI/PET/Serology | China (Harbin, Heilongjiang province) | 30         |
ogy at the National Institute of Infectious Diseases, Tokyo rou-
tinely performs diagnostic tests requested for parasitic diseases
from domestic and foreign medical institutions, and cysticerc-
osis and taeniasis also are acceptable for diagnosis.

The purpose of this article is to overview the current status
of cysticercosis/taeniasis in Japan and to update the data that
was reported in 2005 [5] based on the cases cited in PubMed
(National Library of Medicine) and Japana Centra Revuo Me-
dicina as well as cases diagnosed in our department over the
last 5 years (2007-2011).

CLINICAL CASES

Cysticercosis

According to Nishiyama and Araki [4], as many as 389 cases
of cysticercosis were reported in Japan from 1908 to 1997. How-
ever, 24 cases reported between 1943 and 1979 were not in-
cluded in the study. Furthermore, 41 cases, including 10 cases
diagnosed by our department, have been newly confirmed be-
tween 1997 and 2011 (cases 26-66 in Table 1) [7-40]. Taken
together, this gives a total of 454 cysticercosis cases that have
been reported in Japan between 1908 and 2011. Table 1 shows
66 of the cysticercosis cases that have been reported over the
last 22 years (1990-2011) along with cases confirmed by our
department between 2007 and 2011.

| Case No. | Year | Patient (Nationali-
ty/Age/Sex) | Type of cysticercosis | Diagnostic criteria | Presumed locality of infection | References |
|----------|------|----------------|----------------------|--------------------|-------------------------------|------------|
| 47       | 2005 | Filipino/9/F   | NCC (solitary)       | CT/MRI/Pathology/DNA | Philippines                   | 31         |
| 48       | 2006 | Japanese/24/F  | NCC (solitary)       | MRI/Pathology/DNA   | Indonesia or Korea            | 32         |
| 49       | 2006 | Indian/38/F    | NCC (multiple)       | CT/MRI/DNA         | India                         | 33         |
| 50       | 2006 | Brazilian/42/F | NCC (racemose-type)  | CT/MRI/Pathology/DNA| Brazil                        | 34         |
| 51       | 2007 | Japanese/38/F  | NCC (solitary)       | CT/MRI/Pathology/DNA| Nepal                         | 35         |
| 52       | 2007 | Japanese/84/M  | SCC (systemic)       | CT/X ray/DNA       | Japan (Okinawa)               | 36         |
| 53       | 2007 | Japanese/31/F  | NCC (multiple)       | CT/MRI             | Japan (Okinawa)               | This study |
| 54       | 2007 | Japanese/31/F  | NCC (multiple)       | CT/MRI             | India                         | This study |
| 55       | 2008 | Indian/44/F    | NCC (multiple)       | MRI/Serology/DNA   | India                         | 37         |
| 56       | 2008 | Chinese/30/M   | NCC (multiple) and SCC (multiple) | CT/MRI/X ray/Serology | China                        | This study |
| 57       | 2008 | Japanese/39/F  | NCC (multiple)       | CT/MRI/PET/Serology| Asian or African countries     | This study |
| 58       | 2009 | Japanese/24/M  | Ocular and taeniasis | Fundusclope/US/Serology | Malawi                       | 38         |
| 59       | 2009 | Korean/38/M    | SCC (multiple)       | CT/MRI/SEM/Pathology| Korea                        | 39         |
| 60       | 2009 | Japanese/20/F  | NCC (multiple) and taeniasis | CT/MRI/Serology/Capsule endoscopy/India/DNA | This study |
| 61       | 2009 | Japanese/61/M  | NCC (multiple, racemose-type) | CT/MRI/US/Serology/Pathology/DNA | India, Thailand, China or Vietnam | This study |
| 62       | 2010 | Japanese/53/M  | NCC (racemose-type)  | CT/MRI/Pathology/Serology/DNA | Japan (Uruma, Okinawa)       | 40         |
| 63       | 2010 | Japanese/58/F  | SCC (multiple)       | CT/MRI/X ray/DNA   | Japan (Akita or Okinawa)      | This study |
| 64       | 2010 | Chinese/46/F   | NCC (multiple) and SCC (multiple) | CT/MRI/US/Serology | China (Harbin, Heilongjiang province) | This study |
| 65       | 2010 | Japanese/31/M  | NCC (multiple), SCC(multiple) and taeniasis | CT/MRI/Serology/DNA | India                        | This study |
| 66       | 2011 | Nepalese/35/M  | SCC (solitary)       | CT/US/Serology/Pathology/DNA | Nepal                       | This study |

Table 1. (Continued from the previous page) Demographic and clinical data for cysticercosis cases reported in Japan (1990-2011)
Table 2. Demographic and clinical data for taeniasis reported in Japan (1990-2011)

| Case No. | Year   | Patient (Nationality /Age/Sex) | Etiologic agent (diagnostic criteria) | Presumed locality of infection | References |
|----------|--------|---------------------------------|---------------------------------------|-------------------------------|------------|
| 1        | 1990   | Japanese/72/M                   | *T. saginata* (Morphology)            | ?                             | 63         |
| 2        | 1990   | Korean/52/M                      | *T. saginata* (Serology/Morphology)   | ?                             | 64         |
| 3        | 1990   | Japanese/34/M                    | *T. saginata* (Morphology)            | Ethiopia                      | 65         |
| 4        | 1990   | Japanese/32/M                    | *T. saginata* (Morphology)            | Japan                         | 65         |
| 5        | 1990   | Japanese/26/M                    | *T. saginata* (Morphology)            | Ethiopia or Somalia           | 65         |
| 6        | 1992   | Japanese/10/F                    | *T. saginata* (Morphology)            | Japan                         | 66         |
| 7        | 1994   | Japanese                        | *T. saginata* (Morphology)            | Iran                          | 53         |
| 8        | 1994   | Japanese                        | *T. saginata* (Morphology)            | ?                             | 53         |
| 9        | 1994   | Japanese                        | *T. saginata* (Morphology)            | ?                             | 53         |
| 10       | 1994   | Japanese                        | *T. saginata* (Morphology)            | France or Germany             | 53         |
| 11       | 1994   | Japanese                        | *T. saginata* (Morphology)            | Germany                       | 53         |
| 12       | 1996   | Japanese/53/F                    | *T. saginata* (Morphology)            | ?                             | 67         |
| 13       | 1996   | Japanese/26/M                    | *T. saginata* (Morphology)            | Bolivia                       | 68         |
| 14       | 1996   | Japanese/47/M                    | *T. saginata* (Morphology)            | Cote D’Ivoire                 | 69         |
| 15       | 1997   | Japanese/23/F                    | *T. saginata* (Morphology)            | Europe                        | 70         |
| 16       | 1998   | Brazilian/45/M                   | *T. saginata* (Colonoscope/Morphology)| Brazil                        | 71         |
| 17       | 1998   | Japanese/34/M                    | Probably *T. solium* with NCC          | China (Jiujiang, Jiangxi Province) | 10         |
| 18       | 2001   | Filipino/32/F                    | *T. saginata* (Morphology)            | Philippines                    | 72         |
| 19       | 2001   | Japanese/26/M                    | *T. saginata* (Morphology)            | Japan or India                 | 73         |
| 20       | 2001   | Japanese/47/M                    | *T. saginata* (Morphology)            | Indonesia                     | 73         |
| 21       | 2001   | Japanese/30/M                    | *T. saginata* (Morphology)            | Ethiopia                       | 73         |
| 22       | 2001   | Japanese/60/M                    | *T. saginata* (Morphology)            | Japan                         | 73         |
| 23       | 2002   | Japanese/30/M                    | *T. saginata* (Morphology)            | Ethiopia                       | 74         |
| 24       | 2002   | Japanese/51/M                    | *T. saginata* (Morphology)            | Thailand                       | 74         |
| 25       | 2002   | Japanese/46/M                    | *T. saginata* (Morphology)            | Africa                        | 75         |
| 26       | 2003   | Japanese/24/F                    | *T. saginata* (Morphology)            | Vietnam                       | 77         |
| 27       | 2007   | Japanese/45/M                    | *T. saginata* (DNA)                   | Thailand or Indonesia          | 76         |
| 28       | 2007   | Cambodian/16/M                   | *T. saginata* (DNA)                   | Cambodia                       | 94         |
| 29       | 2007   | Japanese/58/M                    | *T. saginata* (DNA)                   | Korea                         | 94         |
| 30       | 2007   | Japanese/32/M                    | *T. saginata* (DNA)                   | Ethiopia                       | 94         |
| 31       | 2007   | Japanese/33/M                    | *T. saginata* (DNA)                   | Cambodia or Ethiopia           | 94         |
| 32       | 2007   | Japanese/40/F                    | *T. saginata* (DNA)                   | China, Kenya, Monaco or Croatia | This study |
| 33       | 2007   | Japanese/25/M                    | *T. saginata* (Endoscope/Morphology)  | Laos                          | 78         |
| 34       | 2008   | Japanese/26/F                    | *T. saginata* (DNA)                   | Nicaragua, Laos or Indonesia  | This study |
| 35       | 2008   | Japanese/26/M                    | *T. saginata* (DNA)                   | Indonesia                     | This study |
| 36       | 2008   | Japanese/45/M                    | *T. saginata* (DNA)                   | Vietnam or China              | This study |
| 37       | 2009   | Japanese/24/M                    | *Taenia sp.* (Morphology) with ocular type | Malawi                       | 38         |
| 38       | 2009   | Japanese/63/M                    | *T. saginata* (DNA)                   | Thailand                       | This study |
| 39       | 2009   | Japanese/57/M                    | *T. saginata* (DNA)                   | Thailand                       | This study |
| 40       | 2009   | Japanese/49/M                    | *T. saginata* (DNA)                   | Thailand                       | This study |
| 41       | 2009   | Japanese/20/F                    | *T. solium* (Capsule endoscopy/DNA) with NCC | India                        | This study |
| 42       | 2010   | Japanese/58/M                    | *T. asiatica* (DNA)                   | Japan                         | 81, 84     |
| 43       | 2010   | Japanese/41/F                    | *T. asiatica* (DNA)                   | Japan                         | 81, 84     |
| 44       | 2010   | Japanese/55/M                    | *T. asiatica* (DNA)                   | Japan                         | 81, 84     |
| 45       | 2010   | Japanese/40/M                    | *T. asiatica* (DNA)                   | Japan                         | 81, 84     |
| 46       | 2010   | Japanese/31/M                    | *T. asiatica* (DNA)                   | Japan                         | 82, 84     |
| 47       | 2010   | Japanese/41/M                    | *T. asiatica* (DNA)                   | Japan                         | 83         |
| 48       | 2010   | Japanese/28/M                    | *T. asiatica* (DNA)                   | Japan                         | 83         |
| 49       | 2010   | Japanese/30/M                    | *T. asiatica* (DNA)                   | Japan                         | 83, 84     |
| 50       | 2010   | Japanese/60/M                    | *T. asiatica* (DNA)                   | Japan                         | 83         |

(Continued to the next page)
Table 2. (Continued from the previous page) Demographic and clinical data for taeniasis reported in Japan (1990-2011)

| Case No. | Year | Patient (Nationality / Age/Sex) | Etiologic agent (diagnostic criteria) | Presumed locality of infection | References |
|----------|------|---------------------------------|--------------------------------------|--------------------------------|------------|
| 51       | 2010 | Japanese/39/F                   | T. asiatica (DNA)                    | Japan                          | 83, 84     |
| 52       | 2010 | Japanese/24/F                   | T. asiatica (DNA)                    | Japan                          | 83         |
| 53       | 2010 | Japanese/31/M                   | T. solium (endoscopy/DNA) with NCC   | India                          | This study |
| 54       | 2010 | Japanese/39/M                   | T. asiatica (DNA)                    | Japan                          | 84         |
| 55       | 2010 | Japanese/56/M                   | T. saginata (DNA)                    | Thailand                        | This study |
| 56       | 2010 | Japanese/26/F                   | T. asiatica (DNA)                    | Japan                          | 84         |
| 57       | 2010 | Japanese/43/F                   | T. asiatica (DNA)                    | Japan                          | 84         |
| 58       | 2010 | Filipino/31/F                   | T. asiatica (DNA)                    | Philippines                     | This study |
| 59       | 2011 | Japanese/46/M                   | T. saginata (DNA)                    | India                          | This study |
| 60       | 2011 | Japanese/35/M                   | T. saginata (DNA)                    | Thailnd                         | This study |
| 61       | 2011 | Japanese/52/M                   | T. saginata (DNA)                    | Malaysia                        | This study |
| 62       | 2011 | Japanese/24/F                   | T. saginata (DNA)                    | Indonesia (Bal)                 | This study |
| 63       | 2011 | Japanese/41/M                   | T. saginata (DNA)                    | Senegal                         | This study |
| 64       | 2011 | Thai/21/M                       | T. solium (DNA)                      | Thailand                        | This study |
| 65       | 2011 | Japanese/33/M                   | T. saginata (DNA)                    | Sudan                           | This study |
| 66       | 2011 | Japanese/54/M                   | T. asiatica (DNA)                    | Japan                           | This study |
| 67       | 2011 | Japanese/38/M                   | T. asiatica (DNA)                    | Japan                           | This study |
| 68       | 2011 | Ethiopian/24/F                  | T. saginata (DNA)                    | Ethiopia                        | This study |
| 69       | 2011 | Japanese/12/M                   | T. asiatica (DNA)                    | Japan                           | This study |
| 70       | 2011 | Japanese/54/M                   | T. asiatica (DNA)                    | Japan                           | This study |
| 71       | 2011 | Ethiopian/42/F                  | T. saginata (DNA)                    | France                          | This study |
| 72       | 2011 | Ethiopian/26/F                  | T. saginata (DNA)                    | Ethiopia                        | This study |
| 73       | 2011 | Japanese/41/F                   | T. asiatica (DNA)                    | Japan                           | This study |

serologic, and histopathologic examinations. In our department, molecular identification of the etiologic agents is routinely performed, if surgically removed materials are available [46-48]. Indeed, the usefulness of molecular methods for diagnosing the causative agents has successfully been demonstrated by the identification of 2 genotypes of T. solium cysticercus as well as confirmation of the agents in paraffin-embedded sections [24,25,28,31,33-35,37,40]. In addition, the localities where the patients were infected can also be inferred based on the DNA sequences of the causative agents [32,49].

In SCC, X-ray examinations have revealed the presence of rod-like, scattered, calcified lesions in the soft tissues of the extremities (Fig. 1E; G; Fig. 2D, F). These calcified cysts have histopathologically been confirmed to be T. solium in cases 16-17 [42], 26 [7], 52 [36], and 44 [27,28] (Fig. 2A, C, E).

Two types of T. solium cysticercus, cellulose- and racemose-types, are known to exist. The cellulose-type cysticercus is characterized by a single bladder measuring 3 to 18 mm in diameter with an invaginated scolex and primarily found in the cerebral parenchyma and musculature. The racemose-type presents as large multilobulated cystic lesions lacking a scolex and appears to prefer the cisternal and ventricular systems or subarachnoid space [2]. Indeed, the racemose-type cysticercus is frequently found in the subarachnoidal spaces as multilobulated lesions (Fig. 1C, D). Although cysticercosis due to racemose-type T. solium cysticercus is relatively rare, 8 cases have been documented in Japan in cases 8 [50,51], 15 [52], 18 [53], 19 [54], 39 [21], 50 [34], 61, and 62 [40] (Table 1; Fig. 1C, D; Fig. 2C). Of these, mitochondrial DNA analysis using histopathologic sections revealed that etiologic T. solium was the Asian genotype in 3 cases, 50 [32], 61, and 62 [40], and American/African genotype in case 50 [34] (Table 1). The racemose-type cysticercus is considered to be an aberrant, multilobular, non-viable T. solium cysticercus, possibly the degenerated form of a cysticercus in the basilar subarachnoid space. Molecular analysis using formalin-fixed and paraffin-embedded histopathologic specimens has proved that the racemose-type cysticercus is T. solium in cases 50 [34], 61, and 62 [40].

Most of the cysticercosis cases in Japan are imported cases, meaning that the patients either lived in or visited countries where cysticercosis and taeniasis are still endemic, and where they are presumed to have been exposed to T. solium eggs. However, 13 cases have suggested that infection occurred within Japan (cases 1 [55], 8 [50,51], 10 [56], 12 [57], 20 [54], 21 [58], 22 [59], 23 [60], 28 [9], 40 [22], 52 [36], 53, and 62 [40]. NCC was diagnosed by imaging findings (Fig. 1), serology, histopa-
Thelology (Fig. 2A, C, D, E), and molecular analysis.

Taeniasis

Table 2 shows 73 clinical taeniasis case reports that have been published in journals between 1990 and 2011 and diagnosed by our department between 2007 and 2011. In addition to these, 26 cases have been reported [61,62]. The most commonly encountered taeniasis cases were *T. saginata* infections and 48 cases (65.8%) have been confirmed to date (Table 2). Of these 48 cases, 45 were imported cases [63-78]. Although the route of infection is unknown, the possibility also exists that 4 of these cases may be attributable to domestic infections; cases 4 [65], 6 [66], 19 [73], and 22 [73]. *T. solium* taeniasis is extremely rare in Japan and only 1 case was reported in Okinawa in 1988 [79]. However, taeniasis solium cases with either NCC, SCC, or ocular cysticercosis have been confirmed, and all these were imported in cases 29 [10], 58 [38], 60, and 65 (Table 1) and cases 17 [10], 41, 53, and 64 (Table 2). Taeniasis caused by *T. asiatica* has been also recently successively confirmed in Japan and this will be discussed in the following chapter.

Taeniasis is usually diagnosed based on proglottid morphology. However, since *T. saginata*, *T. solium*, and *T. asiatica* are all morphologically similar, it is not always possible to accurately differentiate them. As a result, more reliable molecular diagnoses are currently employed to differentiate between taeniasis infections in our department [46-48]. Most recently, *T. solium* tapeworms have been observed in the small intestine using capsule endoscopy in cases 41 [23] and 53.

**CURRENT STATUS OF T. ASIATICA INFECTION IN JAPAN**

Although *T. asiatica* was not previously considered to occur in Japan [5], retrospective molecular analyses of proglottids revealed that 2 *T. asiatica* infections occurred in Tottori Prefecture on Honshu Island, Japan, in 1968 and 1996 [6]. Unfortunately, it is unknown whether the 2 Japanese cases were domestic infections or imported cases. As the number of Japanese travelers visiting Asian countries has increased, so too has the number of people from other Asian countries visiting Japan. This
may mean that the likelihood of encountering cases of imported *T. asiatica* is increasing. Surprisingly, from June 2010 to December 2011, an increasing number of human cases with taeniasis have been diagnosed in the Kanto region, including Tokyo and the neighboring 5 prefectures (Gumma, Tochigi, Saitama, Chiba, and Kanagawa) in central Honshu [80-84]. Of 31 taeniasis cases, 20 were attributed to *T. asiatica*. *Taenia asiatica* tapeworms were identified based on nucleotide sequence analysis of the mitochondrial cytochrome *c* oxidase subunit 1 gene [25] and allelic analysis of the 2 nuclear genes for elongation factor 1-α and ezrin-radixin-moesin-like protein genes [85].

Nineteen out of 20 patients infected with *T. asiatica* were Japanese nationals residing in the Kanto area, and 1 was a Filipino woman living in same area (Tochigi). Fifteen patients stated that they frequently ate raw pig liver (*sashimi*). Sixteen had never been overseas or, if they had undertaken any international travel, they traveled to countries where *T. asiatica* is not endemic. The infection in the Filipino woman who has returned to the Philippines several times was also considered to have been occurred in Japan.

The occurrence of taeniasis due to *T. asiatica* infection is thus considered to have occurred within Japan by the following reasons: i) most of the patients had never been overseas or traveled to areas where *T. asiatica* is not endemic, ii) most patients had histories of eating raw pig liver, iii) based on interviews with patients and meat inspectors, pigs that had been produced and slaughtered in the Kanto region were strongly suspected to be possible sources of infection, iv) although Japan imports pork from Canada, Mexico, and Europe, no raw pig liver is imported from these countries. At present, the reasons why *T. asiatica* infections successively occurred in the Kanto region, a region within which the disease was not reported previously, have not yet been satisfactorily clarified.

Considering that patients have occurred now, it is possible that the workers and pigs on farms in the Kanto region currently constitute the *T. asiatica* reservoirs responsible for these infections. We have been investigating the prevalence of *T. asiatica* metacestodes in pigs from these farms in collaboration with local meat inspection centers. In addition, we have also disseminated information describing precautions against *T. asiatica* infections in Infectious Agents Surveillance Reports (http://ids.nih.go.jp/iasr/32/374/kj3741.html) published by the Infectious Diseases Information Center at the National Institute of Infectious Diseases [80-84].
CONCLUSIONS

It is expected that cysticercosis and taeniasis will primarily be detected as imported cases with the increasing numbers of Japanese travelers to foreign countries where these diseases are endemic or visitors from these areas increase. The occurrence of human infections due to *Taenia asiatica* is currently restricted to the Kanto region in Japan, and the origins of infection have not yet been clarified. Thus, further occurrence of the disease is likely to occur, medical practitioners should be aware of the importance accurately identifying the causative agent responsible for infection.

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