FISH - AND SHELLFISH - BORNE TREMATODE INFECTIONS IN CANADA

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Abstract. Food-borne trematode infections are endemic in various parts of the world, particularly Southeast Asia. Despite the high prevalence, morbidity and total costs of these infections, they remain poorly recognized by public health authorities and consumers. Factors such as poor sanitation and traditional methods of food preparation hasten the spread of food-borne trematode infections in endemic regions and must be carefully examined in order to develop effective control strategies. There is also a growing risk to consumers in non-endemic countries as a result of international trade. A considerable quantity of freshwater fish and shellfish is imported into Canada from endemic countries in Southest Asia. Some of these products are imported fresh or processed in such a way that the infective metacercariae may not be destroyed. Further, current inspection procedures in Canada may not detect the presence of all parasites in imported fish productes. Therefore, there may be a risk of infection if the fish or shellfish is consumed raw or lightly cooked. Many of the cases of infection in Canada involve recent immigrants from endemic regions who have become infected either before arriving or through the consumption of treaditional or ethnic dishes prepared from imported products. International travel and the increasing availability and interest in ethnic foods also contribute to the risk of infection in all Canadians. In addition to these imported trematodes, a number of species are found in freshwater fishes and shellfish in Nouth America and have also caused illness in humans. Although the prevalence of infection remains relatively low in Canada, the need for an increased general awareness of food-borne trematode infections and their causes is indicated.

INTRODUCTION

It has been estimated that over 50 million people world-wide are currently infected with food-borne trematodes (Lima dos Santos, 1995). The majority of these infections result from the consumption of raw or lightly cooked freshwater fish or shellfish (crustaceans) containing viable metcercariae. Depending on the parasite species, these infections may occur in the liver, lungs, small intestine, and occasionally the brain or other tissues, and produce symptoms ranging in severity from mild to debilitating and life-threatening. The direct or indirect cost of diseases caused by food-borne trematodes is thought to be very high (WHO, 1993a, b). In addition to medical costs, loss of income and productivity exert a heavy burden on the economy of endemic countries such as Thailand, where the total cost of liver fluke infections alone may be as high as USS 84.6 millon per year (Loaharanu and Sornmani, 1991).

Despite the prevalence and high cost, particularly in Southeast Asia, food-borne trematode infections are poorly recognizied by public health authorities and consumers alike. This lack of information probably represents the single most important obstacle in the effective control of this problem. A number of factors impact on the spread of food-borne trematode infections and each of these must be carefully examined in order to develop control strategies (Rim *et al*, 1994).

There is also a growing risk to consumers in non-endemic regions as a result of international trade. In Canada, an increasing quantity of freshwater fish and shellfish is being imported from endemic regions. While much of it is frozen or canned, some is imported fresh or processed in such a way that metacercariae are not killed. Further, since current inspection procedures for imported freshwater fish and shellfish may not detect the presence of all parasites, there is a risk of infection if the product is subsequently consumed raw or lightly cooked. Many of the cases of food-borne trematode infections which have been diagnosed in Canada have involved recent immigrants from endemic regions. While most of these individuals will probably have become infected before arriving, some cases have developed in Canada through the consumption of traditional dishes prepared using products imported from endemic regions. The increasing interest in ethnic dishes containing raw or lightly cooked fish or shellfish, however, contributes to the risk of infection by all Canadians. Travel and tourism to endemic regions is

also increasing and constitutes a further risk to those who consume traditional foods during their travels.

In addition to those infections resulting from the consumption of imported products, some trematodes are present in fish and shellfish in North America and have also been responsible for infections in humans.

TREMATODES OF PUBLIC HEALTH CONCERN

1. Liver flukes

Clonorchis sinensis

Human infections with the Chinese liver fluke are highly prevalent in China (Li, 1991), Korea (Chung and Soh, 1991; Soh, 1991), Taiwan (Chen, 1991a,b), Vietnam and Japan. Over 5 million people are infected in China alone (WHO, 1993a,b). It is also an important parasitic infection in Chinese communities overseas (WHO, 1993a,b). An increasing number of human cases are being diagnosed and reported in non-endemic areas such as North America and western Europe (Sirisinha *et al*, 1991). In Canada, Duchastel (1984) reported that *C. sinensis* was the most common parasitic infection among Hong Kong residents who applied to emigrate during 1979-1981. Of the 25,095 individuals examined, 13.4% yielded a positive stool sample for *C. sinensis* ova. This parasite was also listed among the ten most prevalent parasites detected in immigrants to Quebec in 1976 and 1977 (Gyorkos, 1978). Most of these infections occurred in immigrants from Hong Kong and China. Croll and Gyorkos (1979) reported that *C. sinensis is* not transmitted in Canada and is found, most frequently, in immigrants to Canada from the Far East. Unspecified trematodes of the *Clonorchis/Opisthorchis* group have also been identified in 30 states in the United States, and were the most frequently identified trematode in a recent national survey (Kappus *et al*, 1991, 1994). A total of 1,226 stool specimens, out of 216,275 examined, were positive for this trematode group.

Opisthorchis spp

Opisthorchis viverrini is prevalent in Southeast Asia, particularly in Thailand, Lao PDR, and Cambodia (Khamboonruang, 1991; Scholz *et al*, 1991; WHO 1993a,b). Over 7 Million people are thought to be infected in Thailand alone (WHO, 1993a). The prevalence is particularly high in northeast Thailand where freshwater fish is the most common source of animal protein. Another species, *O. felineus,* is found mostly in eastern Europe and the former Soviet Union, where approximately 2 million people are infected (WHO, 1993a,b). Although they are not always distinguished from clonorchiasis, infections with *Opisthorchis* spp are apparently being reported more frequently in North America and western Europe.

Metorchis conjunctus

The Canadian liver fluke was recently identified in an outbreak situation in Quebec (McLean *et al*, 1996). A group of Korean nationals consumed raw white sucker, *Catostomus commersoni,* freshly caught in a small river north of Montreal. After an incubation period of 1-15 days, 17 of the 19 individuals became symptomatic. Symptoms included abdominal pain, fever, headache, anorexia, diarrhea, nausea, and backache. Symptoms resolved spontaneously or following treatment with praziquantel. A direct relationship was found between the quantity of fish eaten and the severity of symptoms. An examination of unconsumed fish revealed an average of over 7 metacercariae per gram of flesh.

A number of earlier incidents of infection in Canada have also been documented. Eaton (1975) reported the presence of *M. conjunctus* eggs in a group of native Indians in northern Saskatchewan. Much of the fish consumed by these people was smoked over an open fire witout any further cooking. About one third of the members of this group (24 cases) were found to be infected, with some families having all members infected. Sucker was a regular item in the diet of these people. All of the cases reported were sub-clinical. Several cases of infection with *M. conjunctus* were diagnosed at the Toronto Public Health Laboratory (Scholten and Yang, 1975). Naiman *et al* (1980) reported one case of infection in a native Indian child who had intermittent bouts of mild diarrhea. Presumably, the infection was acquired durring one of his summer visits to a reservation in northern Manitoba.

M. conjunctus has been found in Canada from Saskatchewan to the Atlantic coast and from the Arctic to the US border (Eaton, 1975). It has also been reported from the Eastern United States as far south as North Carolina.

2. Lung flukes

Paragonimus spp are lung flukes which occur in humans and numerous other mammals. Human paragonimiasis may be caused by several different species of *Paragonimus* (WHO, 1993a). This disease has been reported from 39 countries (Rim *et al*, 1994). These parasites are endemic in most Asian countries, including Thailand (Ekarohit *et al*, 1991;

Khamboonruang, 1991) Japan (Kamiya and Ooi, 1991; Nawa, 1991), Korea (Chung and Soh,1991; Soh, 1991), and China (Xu, 1991), as well as a few countries in West Africa (Sachs and Cumberlidge, 1990; Pozio, 1991). Approximately 22 million people are thought to be infected in these regions (WHO, 1993a,b). In the western hemisphere, it has been reported from most countries, but most notably from Ecuador and Peru (WHO, 1993a,b). In Canada, Beland *et al* (1969) described four cases of paragonimiasis in the province of Quebec. One of these patients had never been outside of Quebec. Through questioning, it was revealed that he had sold live snails and crustaceans from an exotic food section of a department store. Although he did not consume these items, he may have accidentally ingested water contaminated with these animals. Another case involved an Italian man who had immigrated to Canada three years earlier. As in the first case, the definite source of this infection could not be determined. Two other cases involved immigrants from endemic regions who had, presumably, acquired infections there. One patient had immigrated to Canada from Malaysis a year before hospitalization. The other patient was a Filipino woman who had immigrated to the United States, and eventually to Canada, a few years before hospitalization. While studying these cases, Beland *et al* (1969) examined several snails from the St Lawrence River in Quebec. A large number of sporocysts were observed in the tissues of a number of these snails. As a result of these findings, and some earlier studies reporting *Paragonimus* metacercariae in crayfish from Michigan, these authors concluded that there was a possibility of further domestic cases occurring in North America. In the United States, Johnson *et al* (1982) described several cases of paragonimiasis among Laotian refugees in Minnesota. Pachucki *et al* (1984) reported on an infection of *Paragonimus* in an American man who had no history of travel outside the United States. This individual was apparently infected after eating raw crayfish in Missouri. This infection was described as American paragonimiasis and appeared to be caused by a species other than *P. westermani*, which is common in Asia.

3. Intestinal flukes

Echinostoma spp

At least 16 species of echinostomes have been reported in human infections (Cayney, 1991). The most common species reported in Southeast Asia include *E. malayanum* and *E. ilocanum* (Waikagul, 1991). Infections with *E. hortense* and *E. cinetorchis* have been reported in Korea and Japan (Chai and Lee, 1991). Human infections occur in Asia, North Africa, and in the Americas (WHO, 1993a). Although they are considered rare, several cases of infection with *Echinostoma* spp have been diagnosed in Canada at the Toronto Public Health Laboratory (Scholten and Yang, 1975). One other case was reported in a 6 years old boy in the province of Alberta (Eaton, 1972). An outbreak of gastroenteritis occurred among a group of American tourists returning from a trip to Kenya and Tanzania in 1983 (Poland *et al*, 1985). A diagnosis of echinostomiasis was based on the presence of echinostome-like eggs in stools.

Metagonimus spp

Metagonimus yokogawai is the most common species of intestinal trematode reported in Korea (Chung and Sho 1991; Chai and Lee, 1991). Endemic foci include streams in coastal areas of Korea where sweetfish are found. In Canada, Beare (1978) reported two cases of infection with *M. yokogawai* out of 144 overseas immigrants to the province of Alberta. Goldsmith (1978) reported a case of metagonimiasis in a woman from California who first developed symptoms during travel in Southeast Asia. This patient endured recurrent diarrhea for one and a half years before a diagnosis was made. As she had been careful to avoid eating raw fish during her travels, the source of her infection was not clear, although salad contaminated with metacercariae from a cutting surface was suggested.

Heterophyes spp

Human infections occur in Asia, North Africa, and in the Americas (WHO, 1993a). *H. heterophyes* is prevalent in Egypt and the Middle East, while *H. nocens* has been reported in Korea and Japan (Chai and Lee, 1991). Very few cases have been reported in Canada. Sekle *et al* (1978) reported one case of infection with *Heterophyes* sp. out of 140 recent immigrants to Manitoba. Similarly, Beare (1978) found two cases of infection with *H. heterophyes* out of 144 overseas immigrants to the province of Alberta. A single case was reported in the United States (Adams *et al*, 1986). While this individual had never travelled outside of the continental United States, she had apparently become infected while eating sushi at a local Japanese restaurant which served a variety of freshwater and saltwater fishes flown in from the Orient.

Nanophyetus salmincola

Nanophyetus salmincola occur as adults in the gut

of humans and other fish-eating mammals and birds. In dogs the parasites themselves rarely cause clinical disease but may act as vectors of an often fatal rickettsial disease. Cercariae are shed from snails and penetrate the skin of the second intermediate hosts, which include freshwater fishes such as salmon or trout. The flesh and viscera of these fishes may become heavily infected with metacercariae. Human infections with *N. salmincola* have been reported for many years in parts of the former Soviet Union, and more recently in the northwestern United States. Eastburn *et al* (1987) reported 10 cases of infection in the state of Oregon in which eggs typical for *N. salmincola* were recovered from stool specimens. Eight of the ten patients had a history of consumption of raw, incompletely cooked, or smoke salmon, steelhead trout, or steelhead eggs. The adult flukes recovered from a treated patient were subsequently identified as *N. salmincola.* Deardorff and Kent (1989) indicated that within one year of the original report, the number of human cases in the United States had increased to greater than 20.

EPIDEMIOLOGY AND CONTROL

While the majority of infections with fish-and shellfish-borne trematode occur in Southeast Asia, other endemic regions exist in the former Soviet Union, South America and Africa. A variety of conditions have allowed these infections to become established in these areas. Many of these endemic regions are impoverished and have poor sanitation systems, leading to the fecal contamination of natural water sources used for fishing. Aquacultural fish ponds, which are another very important source of freshwater fish and shellfish in many of these regions, may also become contaminated by means of poor sanitation, or through the intentional use of night soil. In many endemic countries, this use of excreta from domestic animals and from humans is becoming increasingly important for the fertilization of ponds used in aquaculture (Naegel, 1990). It provides an inexpensive source of nutrients to promote zoo- and phytoplankton growth, and a direct feed for some fish species. However, it also represents an important source of pathogens which can be transmitted via aquatic organisms to humans. In China for example, Ling *et al* (1993) reported that up to 10,000 parasite eggs per 100 ml of pond water and sludge were found where ponds had been fertilized with raw night soil. Further fecal contamination of surface waters may result from the proximity of wild and domestic animals which serve as reservoir hosts. Each of these sources of fecal contamination can contribute to the prevalence of metacercariae in the flesh and viscera of freshwater fish and shellfish. Improved sanitation and a reduction in the use of night soil in aquaculture will be important factors in any effective control strategies.

Traditional methods of food preparation involving raw or lightly cooked fish or shellfish are directly responsible for the transmission of viable metacercariae to humans. Prevention of infection may best be accomplished by informing consumers and food handlers of the hazards involved in eating raw and lightly cooked foods and of the methods which should be adopted to reduce the risk of infection. For example, temperature are very effective in destroying parasites in fish and shellfish. Cooking, roasting, grilling, frying, etc are all effective in killing metacercariae if the flesh becomes white or pale in color and assumes a firm texture (Abdussalam *et al*, 1995). When cooking is not desired, through freezing can also be effective. Other methods of processing fish and shellfish such as salting, drying, smoking, fermenting and marinating are common in endemic regions but are unreliable in the destruction of metacercariae. Long-standing traditions of food preparations are, however, very difficult to break and ongoing public health education programs will be required.

While improved sanitation and public health education are very important they can only be considered long term measures. Loaharanu and Sornmani (1991) concluded that, at present, screening and mass treatment is the only feasible control measure in endemic regions. Currently, praziquantel is the drug of choice and has been used successfully on most trematodes (Eastburn *et al*, 1987; WHO, 1993a). Treatment is, however, often complicated by misdiagnosis due to the ambiguity of symptoms. For example, paragonimiasis is often misdiagnosed as tuberculosis, epilepsy or meningitis (Maurice, 1994).

Some endemic countries have already established models for the control of food-borne trematodes, through identification of infected people, treatment with praziquantel, health education, and legislation regarding food safety and the sanitary disposal of sewage (Lima dos Santos, 1995; WHO, 1995). These control programs have proven to be very effective in reducing the prevalence of food-borne trematode infections. As a result, the World Health Organization has called for collaboration among various sectors, including public health, agriculture, fisheries, food industry, food safety, and education, in an effort to reduce the suffering and expense imposed by these infections (WHO, 1995). The concept of Hazard Analysis and

Critical Control Point (HACCP) is presently being evaluated with respect to its feasibility and efficiency in the prevention and control of food-borne trematode infections (Rim *et al,* 1994; Lima dos Santos, 1995).

Incorporation of HACCP-based control measures in aquaculture could significantly reduce the risk of human infection by focusing on a variety of critical control points throughout the production and processing of fish and shellfish.

In non-endemic countries such as Canada, the prevalence of food-borne trematode infections remains relatively low and, while there is some indication that suitable intermediate hosts may be available, it dose not appear likely that these parasites could become well established. This is due primaily to the efficient sanitation systems, the use of commercial feed rather than night soil in aquaculture, and, particularly, the common practice of cooking fish and shellfish before consumption. Further, a consumer recommendation by Fisheries and Oceans Canada states that any fish to consumed raw should be prepared from frozen product. Nevertheless , the importation of freshwater fish and shellfish from endemic regions, the interest in ethnic dishes, and increasing immigration and travel have all contributed to the risk of infection in Canada.

While much of the fish and shellfish imported into Canada from Southest Asia is frozen or canned, thereby killing any metacercariae present, there is a danger that producers in endemic regions wishing to gain a competitive edge could begin shipping fresh, unfrozen fish by air (Maurice, 1994). In fact, between April 1, 1994 and March 31, 1995, over 1,700 kg of freshwater fish were imported into Canada as "fresh" product from various countries in Southeast Asia. These imports included some fishes, such as carp, mullet, and goby, which are common intermediate hosts for trematodes. During this same period, over 40,000 kg of freshwater fish was imported as "other" (cooked, cured, dried, salted, pickled, smoked, spiced, flavored, etc) and over 400 kg was imported as "semi-preserved" (brine, vinegar, sugar, spices, etc). Depending upon the treatment, some of these products could also contain viable metacercariae. Therefore, as the current inspection procedures for imported freshwater fish into Canada may not detect the presence of all parasites, there may be some risk of infection from these products if they are consumed raw or lightly cooked. In addition to fish, there is also some importation of freshwater crustaceans (crabs, crayfish) into Canada from endemic regions. In an effort to reduce the likelihood of human infection with *Paragonimus westermani,* all imports of live freshwater crabs of the genus *Eriocheir* are prohibited under the Canadian Fish Inspection Regulations.

In Canada, and other non-endemic countries, there is an increasing availability and interest in ethnic and traditional foods. Whether these foods are eaten at home or in ethnic restaurants, they may represent a risk to consumers if they are prepared using raw or lightly cooked freshwater fish or shellfish imported from endemic regions. In addition to these imported products, a number of trematodes including *Metorchis conjunctus, Nanophyetus salmincola,* and *Paragonimus* spp are found in freshwater fishes and shellfish in North America and have also been responsible for human infections following the consumption of traditional or ethnic dishes.

The incidence of food-borne trematode infections in immigrants and refugees from Southest Asia is relatively high and probably accounts for the majority of infections in Canada. While many of these infections originated before arriving, some may have developed in Canada. International trevel is also partially responsible for the increased prevalence of food-borne trematode infections in developed countries. The number of tourists to Southeast Asia is increasing rapidly and there is a risk of infection to those individuals who partake in traditional or ethnic foods during their travels.

CONCLUSIONS

Despite the high cost and prevalence of infection in some areas of the world, the public health significance of food-borne trematode infections is poorly recognized, and dissemination of information and continued discussion will be necessary for the development of effective control strategies. Control of food-borne trematodes in endemic regions will involve screening the population and treating infected individuals, as well as the long-term measures of public health education, and legislation regarding food safety and sanitation.

A significant quantity of freshwater fish and shellfish is being imported into Canada from endemic regions and the consumption of these products in a raw or lightly cooked form represents a moderate health risk. While general cooking habits as well as effective sanitation and water treatment systems will probably prevent the establishment of these fish and shellfish-borne trematode in Canada, factors such as immigration, international travel, and the increasing interest in ethnic foods, contribute to the risk of infection. In addition to these imported trematodes, a

number of species are found in freshwater fishes and shellfish in North America and have also caused illness in humans. Although the prevalence of infection remains relatively low in Canada, the need for an increased general awareness of food-borne trematode infections and their causes is indicated.

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