EPIDEMIOLOGY OF PARAGONIMIASIS IN KOREA

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Abstract. In Korea, soybean-sauce soaked freshwater crabs (kejang) have been a favorite delicacy when eating a bowl of rice. This traditional food has been a main source of human paragonimiasis. Until the late 1960s, human paragonimmiasis had been prevalent; at least two million people had contracted the infection as determined by intradermal tests. About 40% of these were egg positive. In the turmoil of the green revolution and industrialization in the 1970s/1980s, ecological damage occurred widely. In many streams, populations of snail and crustacean hosts were reduced to levels almost of extinction. Population reduction of the intermediate hosts was followed by lowered endemicity. Attitudes of people, changed during the period, also reduced chances of paragonimiasis. Survey data in the 1990s indicated that prevalence of human paragonimiasis has lowered to about one 100th of that in the early 1970s. In a referral system, however, about one hundred clinical cases have been diagnosed annually by antibody test (ELISA), undertaken for clinical differentiation from tuberculosis. At least 10% of freshwater crabs sold in local markets are infected with the metacercariae. Paragonimiasis control has benefited in Korea mainly by the untoward effects of water pollution. To place *P. westermani* infections as enzootic, health education and surveillance systems should have a priority.

INTRODUCTION

Human paragonimiasis had been one of the most important endemic helminthiasis of major public health importance in Korea. Its endemicity has been attributed mainly to ecology which maintained susceptible snail and crustacean intermediate hosts as well as definitive hosts. The enzootic cycle of *Paragonimus westermani* was connected to human infections due to traditional food habits. Because of its high prevalence and public health importance, the disease was of significant public concern and a central topic of parasitological research in Korea, resulting in contributions in the field of cerebral paragonimiasis (Oh, 1968 a, b; 1978; Cha *et al*, 1994), control measures (Kim, 1969 a,b), chemotherapy with praziquantel (Rim *et al*, 1981), diagnostic antibody tests (Cho *et al*, 1981; Choi, 1984) and epidemiological surveillance (Walton and Chyu, 1959; Cho *et al*, 1983).

In the early 1960s, when human paragonimiasis began to taper off, bithionol was introduced to Korea and was widely used. During the 1970s and 1980s, with industrialization emerging at a bewildering speed, the ecology was damaged widely. This resulted in a remarkable reduction of human infections. All rivers and streams however, were not polluted. In uncontaminated waters, freshwater crabs persisted (Shim *et al*, 1991).

In such a context, clinical cases of paragonimiasis have been occurring due to persisting tradition of eating the kejang by a limited population. In clinics and hospitals, differentiation of paragonimiasis from pulmonary tuberculosis remains of significance. In this paper, epidemiological aspects of human paragonimiasis in Korea are reviewed briefly.

PARASITES AND ECOLOGY

Two species of the genus *Paragonimus*, *P. westermani* and *P. iloktsuenensis*, have been known in Korea. Of triploid and diploid *P. westermani*, triploidy dominates. Human infections with *P. iloktsuenensis*, of which rodents are definitive hosts, have not been recognized. Therefore, human paragonimiasis in Korea has been caused solely by *P. westermani*. Snail intermediate hosts of *P. westermani* are *Semisulcospira libertina* and other species of the same genus. These snails are thriving in unpolluted, crystal clear freshwater with high oxygen contents, feeding on organic materials precipitated on rock and sand of river and mountain streams. Infection rates of larval *P. westermani* are low. The highest rate ever reported was 0.9% in endemic foci.

Freshwater crustaceans such as crabs (*Eriocheir japonicus* and *E. sinensis*) and crayfish (*Cambaroides similis* and *C. dauricus*) are the second intermediate hosts of *P. westermani*. Unlike in the snail hosts, metacercarial infections in the crustaceans are high sometimes reaching nearly 100% in some areas.

During the period when the nation was becoming industrialized, the beautiful ecology, which kept hosts of *P. westermani*, was damaged . In the early 1970s, the damage was begun by pesticides and herbicides used in cultivating new breeds of rice. At first, these chemicals affected the ecology of rice paddy extensively, eliminating snails and crabs. Subsequent water pollution due to industrial and household waste resulted in further reduction of the freshwater crustacean population in wide areas. During the industrialization, reduction in number of freshwater crustaceans as well as the snail hosts has been the most important epidemiological factor changing the picture of human paragonimiasis in Korea.

Definitive hosts of *P. westermani* include canine and feline species together with humans . Because of long deforestation during and after the wars in the 1940s to 1960s, the number of wild mammals was reduced. Instead, dogs and cats played important roles as reservoirs, which populations were also affected by use of rodenticides. In the 1960s, the egg source for snail infection seemed to be humans rather than the carnivores.

Many paratenic hosts of *P. westermani* keep juvenile worms in their tissue and become a source of human infection. Field observations on the paratenic hosts, however, have not been done in Korea to any extent.

MODE OF TRANSMISSION IN KOREA

In Korea, the high prevalence of human paragonimiasis has been due to eating of freshwater crustaceans. A typical example is the kejang. The kejang is not infective in itself if soaked for longer than two weeks (Loh, 1966). Metacercariae in the crab tissue shrink and die in hypertonic soybean sauce. However, many families eat them within a few days after the soaking. Such an undersoaked kejang may have infective metacercariae. Most of familial paragonimiasis, which occurs sporadically, is the eating of kejang by all members of a family (Sung *et al*, 1989). Some crabs are kept and eaten locally, but since they are expensive, most are sold for cash to markets of major cities which deal with the traditional foods. Sumjin and Imjin Rivers are unpolluted and produce many crabs.

In Korean rural villages, juice of freshwater crayfish was used as a remedy for controlling fever of measles until the 1960s. The crayfish abounded in every stream around the villages. The juice was prepared by filtering crushed crayfish through cloth similar to the process used by parasitologists for isolating metacercariae. This traditional remedy had been an important source of infection, especially in childhood paragonimiasis. Most of acute cerebral paragonimiasis in children (Yun, 1960) and chronic adult cases have a history of taking the juice. In the 1970s, the remedy disappeared because of the popular use of measles vaccine and diappearance of the crayfish in polluted streams. In addition, because family structure turned from multi-generation to two generation families, old ladies could not command such traditional treatment for their grandchildren in a protest of educated daughters-in-law. Nowadays, the crayfish juice is just a textbook example of transmission modes and is no longer practiced.

In the past, children in remote rural areas collected crayfish in mountain streams of villages and roasted them to eat. These habits of mischievous fun could be a source of the infection because they ate them as soon as the surface turned to red. These undercooked crayfish were regarded as dangerous, although infection chances were not high. This traditional practice of rural children has also disappeared and has been replaced by candy, icecream, television and joy sticks.

Eating raw meat of paratenic hosts can be a source of human paragonimiasis. An example was a Japanese paragonimiasis patient who had eaten raw boar meat (Miyazaki and Habe, 1976). Many species of mammals are potential paratenic hosts of *P. westermani*. However, in Korean literature, confirmed cases have not been recorded .

EPIDEMIOLOGICAL SURVEY TOOLS

An area maintaining the life cycle may not be necessarily be wide. This is the reason why an index of endemicity may be different between nearby areas. Another problem met in surveying paragonimiasis is that one diagnostic tool can not determine the entire picture of endemicity. Examination of larvae in the snails is laborious and shows very low rates of infection even in heavy endemic foci. Instead, crustacean infections with the metacercariae is relatively easy to determine and represents very well enzootic or endemic states. Therefore, metacercarial infection rates and their burdens are very important indices in evaluation of regional paragonimiasis.

In human population surveys, at least three techniques have been employed. Usually, an intradermal test is undertaken first although the test is less specific. Because of frequent positive reactions in cured cases and cross-reactivity with *Clonorchis sinensis* infections, the specificity varied from 15% to 45% according to degree of previous chemotherapy. However, the test is sensitive (80-90%) and can screen out suspected cases. The test has also been used in clinical screening.

Sputum or stool microscopy for eggs of *P. westermani* is a standard technique not only in clinical diagnosis but also in epidemiological studies. Egg examinations show a low sensitivity however because eggs are discharged intermittently, and because there may be cases only with extrapulmonary infections. Though insensitive, correct egg identification provides evidence of the active infection.

To overcome low specificity of the intradermal test and low sensitivity of the egg examination, antibody tests, such as complement fixation test, immunodiffusion, indirect fluorescent antibody test, counterimmunoelectrophoresis and ELISA etc, are used (Choi, 1984). The antibody tests are sufficiently sensitive and specific. In population survey, antibody tests can diagnose active paragonimiasis realistically (Cho *et al*, 1983).

Population survey by chest radiograph should be supplemented with the results of egg examination or antibody test because imaging findings are frequently superimposed with pulmonary tuberculosis. In addition, 10-50% of pulmonary paragonimiasis are normal in their findings of chest radiograph.

STATES OF INFECTION IN KOREA

The extent of human paragonimiasis in Korea was first recorded by Kobayashi in 1924 when 7.9% of 353, 729 people examined were sputa-egg positive. This did not represent infection states of general population because sputa only were examined. The survey, however, illustrated the extent and geographical distribution of paragonimiasis and its contemporary importance as a health problem.

In 1959, Walton and Chyu undertook a nationwide survey for paragonimiasis and clonorchiasis by intradermal test. Of 9,711 people tested, 12.9% reacted positively for paragonimiasis which revealed at least two million people in Korea had contracted *P. westermani* infections. At that time, egg positive rates in the positive reactors was 40-45%. Results of local surveys done in the 1960s-1980s were reviewed by Choi (1990). Recent national data done by the intradermal test is not available but presumed to be < 2% in the general population.

In every corner of the country, endemic villages were scattered. Among them, the high endemic areas were located in Cheju Do (Province), in Haenam Gun (County), Koheung Gun, Jangheung Gun, Kangjin Gun and adjacent areas in Cholla Nam Do, Hadong Gun in Kyongsang Nam Do, in Nonsan Gun in Chungchong Nam Do, in Paju Gun and Kangwha Gun in Kyonggi Do and in Samchok Gun in Kangwon Do.

National surveys by stool examination, conducted every five years by the Ministry of Health and Social Affairs and the Korea Association of Health (1993) revealed that the number (and rate) of *Paragonimus* egg positive cases was 23 (0.09%) in 1971, 2 (0.007%) in 1976, 0 in 1981, 1 (0.002%) in 1986 and 0 in 1992, respectively. In the national survey, one random sample represented a thousand people. Therefore, in a sense of statistics, the actual number of egg positive cases in 1981, 1986 and 1992 can be estimated as around a thousand or a few hundreds. In other data from the Korean Association of Health, the numbers of egg positive students in a nationwide stool examination were 1.482 (0.014%) in 1970, 467 (0.004%) in 1975, 241 (0.002%) in 1980, 75 (0.0005%) in 1985 and 16 (0.0002%) in 1990, respectively. In interpreting the data, low sensitivity of stool microscopy should be taken into account. One evident thing was that, during the past 20 years, the rate was lowered to about one

100th. Other data of the Korea Association of Health confirmed the reduction of egg positive rates in a similar rate (Table 2).

Local surveys also revealed that the remarkable changes in the endemicity. For example, in villages of Haenam Gun in the late 1960s, the egg positive rates were estimated as about 20% (Chun, 1970). In 1983, egg positive rate was 0.2% while the rate of positive antibody test was 1% in the same county (Cho *et al*, 1983). Similarly, the egg positive cases in patients of tuberculosis sanatorium were 10% in the late 1950s (Chyu, 1960). It was reduced to 0.3% in the 1980s (Choi *et al*, 1984).

The changing endemicity made it necessary to express the states of infection by incidence rather than conventional prevalence rates. As a result, a detection system of clinical paragonimiasis was set up by employing the complement fixation test, gel diffusion or counterimmunoelectrophoresis (Choi, 1984) or by ELISA (Cho *et al*, 1981). In the late 1970s, the referral system functioned minimally and 2-19 cases were diagnosed in a year. In the late 1980s, a referral system by ELISA has been run efficiently. Since 1989, 70-120 clinical cases have been diagnosed annually (Cho *et al*, unpublished data). Most of them were referred to differentiate paragonimiasis from drug-resistant tuberculosis or from inflammatory lung diseases associated with eosinophilia. Considering the large number of asymptomatic infections and a limited coverage of our system, actual number of the infections should be larger than that we are detecting.

Oh (1969) in a local survey reported 0.8% of positive reactors of the intradermal test for *Paragonimus* were neurologically compatible with cerebral paragonimiasis. Based on the result, in the 1960s, the numbers of cerebral paragonimiasis in Korea were estimated as about 6,000. Recently, in our referral system, 2-7 cases of early active (Cha *et al*, 1994) and 10-15 cases of chronic calcified cerebral paragonimiasis have beend detected annually.

Metacercarial infection in the crabs has also decreased. In 1990, infection rates in the crabs, *Eriocheir japonicus*, purchased in Seoul markets, were 11.8% with 2.1 metacercariae per infected crab. In the 1960s, the infection rates ranged from 36-78% with burdens of 8-23 metacercariae per infected crab.

CONTROL OF PARAGONIMIASIS

The final goal of the control activities against paragonimiasis is making infections purely enzootic. In many countries, *Paragonimus* species infect only carnivorous mammals while human infections do not exist except for a few accidental infections. Therefore, in countries where the eating habit is popular like in Korea, discouraging it by health education should have a priority as a control strategy. In addition, surveillance systems such as a centralized service of the antibody tests for human paragonimiasis are necessary to diagnose and treat the infected cases early and to monitor the incidence. Removing intermediate hosts in streams can block the life cycle, but it accompanies inevitable ecological damage. Retrospectively, Korean example of inadvertent control of human paragonimiasis by water pollution was not desirable indeed.

In Korea, a control program of paragonimiasis was undertaken in hyperendemic village of Cheju Do (Kim, 1969). The objective of the program was blocking the snail infections by a mass chemotherapy. Stopping egg production in human population was hypothesized feasible by using bithionol. About one thousand egg-positive cases were treated in 1964-1973. In the follow-up studies, decreasing tendency was evident in all epidemiological parameters including positive rates of intradermal test, sputum egg examination, and the crab infections with metacercariae. Unfortunately, however, a long-term effect of the mass chemotherapy were confounded by subsequent water pollution and damaged ecology in the local areas. Any way, the program of mass chemotherapeutic control resulted in evidently lowered endemicity as well as lowered morbidity in the local population.

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