Trichinosis in the United States

IRVING G. KAGAN, Ph.D.

AMONG all the intestinal nematodes, *Trichinella spiralis* has probably made the best adjustment for a parasitic existence. All stages of the life cycle are parasitic. The sexually mature worms reside in the small intestine and produce larvae which invade the musculature and internal organs of the host. A recent study of 55 experimentally infected hogs revealed the following distribution of larvae in the tissues: diaphragm, 100 percent; stomach, 18 percent; testes, 15 percent; liver, 11 percent; brain, lungs, wall of the small intestine, each 9 percent; pancreas and aorta, each 8 percent; and heart, 2 percent (*1*).

The definitive hosts for this parasite are usually carnivorous mammals, that is, those that eat the flesh and internal organs of infected animals. A survey of 2,433 mammals representing 42 species in Alaska revealed an incidence of infection of 11.7 percent in 23 species (*2*). Some of the infected hosts were aquatic mammals such as seals and white whales, which are primarily fisheaters, indicating that the epidemiology of *T. spiralis* may involve transfer or transient hosts.

In the United States trichinosis is a disease of man and his domesticated pig as well as a sylvatic disease of many wild animal species. A survey of trichinosis from 1953 to 1955 in Iowa emphasizes the sylvatic nature of this disease. Infected with trichinosis were 14 of 119 rats, 31 of 308 foxes, 1 of 40 opossums, 2 of 29 raccoons, 12 of 85 mink, and 2 of 4 coyotes. Examination of 2,184 pigs revealed 1 infection, and 18 of 1,148 pork products contained trichina larvae (*3*). In the arctic areas the polar bear, dog, and wolf are heavily infected.

The incidence of trichinosis in the American population is not accurately known today. Gould believes that a conservative estimate would place the figure at about 16 percent. But in a postscript he states that the incidence is probably more than double this amount (*4,5*). This means that 25 to 50 million Americans carry trichina larvae in their muscles and internal organs. A majority of these infections are symptomless and subclinical. Although most States do not make trichinosis a reportable disease, between 200 and 300 cases are reported each year to the Public Health Service. These are the recognized cases. Clinically, trichinosis has all the earmarks of so many other diseases that in all probability a large number of cases go undiagnosed. The mortality rate for recognized clinical cases was approximately 5 percent in the United States (*4,5*).

The epidemiology of this disease is very well understood. We know how it is transmitted to man, and we know how to prevent its spread in the swine population. We are improving serologic diagnosis in the suspected patient and have made important advances in the treatment of the disease with ACTH and cortisone. In recent years two comprehensive national conferences on trichinosis were held in Chicago, the first in December 1952 and the second in March 1954. The many facets of the control of this disease were adequately covered in the papers presented at these meetings. In this paper I shall outline the problem and review

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some of the contributions that have been made since those meetings.

Control Measures

Trichinosis in the United States is perpetuated in a very small proportion, 0.63 percent, of the swine population through the feeding of infected scraps of pork collected in garbage (*6*). As of May 31, 1957, the Animal Disease Eradication Division of the U. S. Agricultural Research Service reports that 12,423 farms were feeding garbage in one form or another to swine. Hundreds of communities in the United States sell their garbage and use the funds for civic purposes. It is generally conceded that the prohibition of garbage feeding would drastically cut the incidence of trichinosis in the domesticated pig, but it would probably not eradicate the parasite because of the sylvatic incidence of trichinosis in rats and other scavenging species. The lone infected pig in the Iowa survey (*3*) may well have acquired trichinae by eating a dead infected animal on the farm.

Since a $50 million industry, the collection and use of garbage for swine production, involving approximately 35 percent of the communities of the United States, probably cannot be legislated out of existence, attention has been directed toward another measure, the sterilization of garbage by cooking (*7*). Every State has some type of law or regulation which prohibits the feeding of raw garbage to swine.

Garbage cooked at 100° C. for 30 minutes is freed of living trichina larvae. Approximately 11,747, 94.5 percent, of the 12,423 premises feeding garbage to hogs, report that they are feeding cooked garbage. This salutary situation with respect to the use of cooked garbage was engendered mainly by the necessity of preventing the spread of garbage-borne epidemic disease of pigs, such as hog cholera, vesicular exanthema, foot-and-mouth disease, salmonellosis, tuberculosis, swine erysipelas, and brucellosis. Because of noncompliance by some farmers, the lack of adequate inspection facilities by some State agencies, and the expense of cooking garbage, the control of trichinosis by this method has not been completely successful. Continued education, research, and law enforcement by State and Federal officials will do much to strengthen this very effective method of trichina control.

Inspection of pork products constitutes another means of control. The Federal Government requires that "the respective States allow the sale of garbage-fed hogs for slaughter only at a federally inspected plant or plant having equivalent inspection." In some countries tissue press preparations of each carcass are carefully inspected microscopically for the presence of trichina larvae. In Chile a staff of 22 persons is necessary to process and examine 1,000 pigs a day: 8 trichinoscopists, 4 sample collectors, and 10 assistants preparing 8 slides from each carcass for examination (*8*). It is estimated that an effective program of microscopic inspection in the United States would cost more than $40 million (*9*). For this and other reasons, the microscopic examination of pork has not become a routine procedure in our country.

The freezing of pork is also advocated for killing trichina larvae in infected carcasses. As early as 1914, research by the U. S. Bureau of Animal Industry indicated that refrigeration of pork at −15° C. (5° F.) for 20 days is an effective safeguard against trichinosis in man (*10*). These studies were the basis for the present practice of holding pork and pork products customarily eaten without cooking by the consumer for 20 days at 5° F., 10 days at −10° F., or 6 days at −20° F. In Canada pork is held at −15° C. for 3 weeks in sealed storage lockers inspected by the government (*11*). Quick freezing at temperatures of −37° C. (−34.6° F.) kills trichina larvae in 2 minutes. In the United States today meat packing plants do not have the space to freeze and store the huge volume of pork processed. The cost to the consumer for freezing pork would be approximately 5 cents per pound. This economic factor plus consumer resistance to the purchase of pork that has been frozen and thawed make this type of control impractical and difficult to initiate (*12*).

Sterilization of carcasses by irradiation has been carefully investigated by Gould and his co-workers (*13*). These workers have estimated that facilities using cesium-137 as the source of radiation, costing in excess of $500,000, can

effectively treat carcasses with 30,000 roentgens, enough radiation to make the larvae incapable of completing their life cycle in the host. The cost to the consumer is estimated at 0.23 cents per pound, and the meat is said to be unaltered, healthful, and palatable.

The most effective and the cheapest control method is the thorough cooking of pork by the consumer. If they were aware of the hazards, many persons would not eat uncooked pork or pork products that have been smoked and not adequately heated prior to processing. Informing the producer on the farm about the dangers of feeding raw garbage to his swine and alerting the housewife, food handler, restaurant owner, and others to the dangers of eating pork not thoroughly cooked are among the control measures recommended by previous conferences on trichinosis. But it should be reiterated that placing the responsibility for control of trichinosis on the consumer is not the most efficient method for controlling the disease.

Treatment and Diagnosis

One aspect of the epidemiology of trichinosis should be emphasized. Eradication cannot be accomplished solely by control measures initiated by the large farmer or food processor. A number of trichinosis outbreaks have been traced to pork products that did not pass through federally inspected plants (*14*). The small farmer with a few pigs which are fed table scraps (uncooked garbage) and butchered in local abattoirs account for some of the incidence of trichinosis in the United States.

Since so many trichina infections are subclinical, the question has been raised regarding the necessity of any kind of control. Magath and Thompson believe that persons infected with small numbers of trichina larvae have an acquired immunity which would be destroyed were the disease controlled (*15*). From a public health point of view such a position is untenable. We must strive for the control of all communicable diseases. There is also to be considered another facet of this complex problem that has received very little attention—the evaluation of the deleterious effects of a subclinical infection in an individual. In the rat, infection with trichina larvae reduces the working ability of the animal 49 to 60 percent. Weight loss induced by exercise is 150 to 170 percent greater than in the controls (*16*).

Little attention has been directed toward the use of long-lasting, broad-spectrum chemotherapeutic agents administered in the feed to eliminate *T. spiralis* adults and other intestinal roundworms in swine. In mice, medicated feed containing 0.15 percent cadmium oxide produced a striking reduction in the number of adults and larvae harbored by infected animals (*17*).

The use of a skin test for the diagnosis of infection in pigs has not received much attention in recent years. Soulsby skin-tested animals in England and reported cross-reactions with *Ascaris* infections (*18*). With the application of newer immunochemical techniques, specific antigens could be prepared for this purpose.

Two flocculation serologic procedures are available for the diagnosis of trichinosis: the method of Sussenguth and Kline (*19*), utilizing cholesterol particles, and the bentonite technique of Bozicevich and others (*20*). The Helminthology Unit at the Communicable Disease Center uses the bentonite flocculation test for the diagnosis of trichinosis. We have found this method effective in detecting antibody during acute infections in man and animals. In an experiment with experimentally infected hogs, flocculating antibody was detected from the second to the sixth week of infection in all animals. After the ninth week antibody could no longer be determined (*21*). As a method of diagnosing active infection, the bentonite technique is excellent, but, for the detection of chronic infections, it does not compare with the technique of Sussenguth and Kline. These workers reported that antibody may be detected in infected hogs 1 year after infection (*19*). Utilization of a rapid serologic technique for the detection of infected animals prior to slaughter might under some circumstances be a useful control procedure.

Conclusion

To be successful, any control program for trichinosis must not conflict with the economics of pork production on the farm or at the proc-

essing plant. The control of trichinosis has benefited more from the measures taken to control vesicular exanthema than from all the recommendations made for the helminth disease. This is heartening because any measure taken against the spread of a garbage-borne virus disease will benefit a helminth garbage-borne disease. Although it may never be economically feasible to quick-freeze all pork in order to kill trichina larvae, the storage of pork in freezing compartments of refrigerators and home freezers is doing much to lower the incidence of trichinosis in our country (*12*).

In the not too distant future, we will have to come to grips with the control of this disease. Control will come when the American people are willing to pay the price of consuming trichina-free pork. Until that time the scientific community must continue working on more efficient methods of control and on instructing the public in methods of protecting its health and well-being.

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