SERIAL FEATURE

Algorithms in the Diagnosis and Management of Exotic Diseases. VII. Trichinosis

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Trichinosis, an infection with the nematode *Trichinella spiralis*, may occur after the ingestion of the undercooked flesh of any carnivore, but it is usually associated with pork. Most infections are asymptomatic but heavy exposure, often occurring in limited epidemics, results in clinical disease characterized by periorbital edema, myositis, and fever. Treatment is unsatisfactory and severe infections may be fatal.

*T. spiralis* has a worldwide distribution with the exceptions of Australia and many of the Pacific islands. It is found throughout the United States but is most prevalent in the northeast and on the west coast. Although the prevalence of trichinosis is declining, it remains one of the most important helminthic infections in the United States because of its potential severity. In a nationwide autopsy survey in 1941, 16% of cadavers were positive for trichinelae, but by 1968 the number of infected cadavers had fallen to 4% [1]. Similarly, the number of reported cases has declined from 500 in 1948 to around 100 in recent years; 20 deaths have been reported during the last 10 years.

Life Cycle

After ingestion of raw or inadequately cooked meat containing viable larvae of *T. spiralis*, the organisms are freed from the cyst wall by acid-pepsin digestion and pass into the small intestine, where they burrow into the villi. After molting, the trichinelae develop into adult worms; males are 1,500 \( \times \) 50 \( \mu \text{m} \) and females 3,500 \( \times \) 60 \( \mu \text{m} \) in size. Each fertilized female worm releases approximately 500 larvae (100 \( \times \) 5 \( \mu \text{m} \) in size) during a period of two weeks, after which the adult worms are eliminated from the gut, probably by immunological mechanisms. The larvae, which seed the skeletal muscles by way of the lymphatics and blood vessels, burrow into individual muscle fibers; during a period of three weeks the larvae increase 10 times in length and become coiled, resistant to acid-pepsin digestion, and capable of infecting a new host. A cyst wall of muscle origin that develops around the larvae may calcify during the next few months or years. Encysted larvae may remain viable for several years, and when they are ingested by other animals the cycle of trichinosis continues.

Epidemiology

Trichinosis is essentially a zoonosis; man is an incidental host. The organism is widely spread in nature among a large number of carnivorous animals, including rats, pigs, bears, cats, dogs, foxes, opossums, and raccoons. In a survey in Iowa, up to 5% of such animals were found to be infected [2]. Pigs become infected chiefly from eating uncooked scraps of pig meat or occasionally wild animals, particularly rats. The vast majority of swine in the United States are grain-fed, and only 0.1% are infected with trichinelae. While the remainder (1.5%) are garbage-fed, legislation introduced in the middle 1950s forbidding the feeding of uncooked garbage has reduced *T. spiralis* infection in pigs from 10% to 0.5%.

Man usually contracts the infection by eating inadequately processed pork; for example, in 1971 pork products were incriminated as the source of infection in 71% of cases reported to
the Center for Disease Control. Beef products such as hamburger may become adulterated with pork through the use of a common meat grinder or the intentional mixing of meats. Bear meat is an occasional cause of epidemics of human trichinosis [3]. Asymptomatic infection probably results from light exposure either as a result of eating inadequately cooked meat in which most but not all of the cysts are destroyed or as a result of dilution of infectious meat in large packing houses. Preexisting immunity may also reduce the infectivity of an inoculum of larvae. Strains of *T. spiralis* with various degrees of infectivity have also been reported. Epidemics occur when families or small communities consume trichinose meat from a common source.

Smoking, salting, and drying do not destroy infective larvae. Meat can be sterilized by adequate freezing; for example, a cut six inches thick is safe after storing at −15 C (the temperature of the average home freezer) for 20 days, but the most effective method is proper cooking. The thermal death point of trichinellae is 55 C, so that meat should be cooked until there is no trace of pink fluid or flesh.

**Disease Syndromes**

The vast majority of infections in man are sub-clinical; the development of symptoms depends mainly on the size of the inoculum of viable larvae. The minimal number of larvae required to produce symptoms is said to be about 100, while a fatal dose is of the order of 300,000. Most of the infected subjects in the 1968 national autopsy survey [1] had low worm burdens: 38% had less than one larva, and 52% had one to 10 larvae per g of muscle; 9% had 10–100 larvae, and only 1% had more than 100 larvae per g of muscle. The clinical features in heavily infected individuals reflect the intestinal and muscle stages in the life cycle of the parasite.

(1) **Intestinal manifestations.** Symptoms attributable to the adult worms in the intestines are much less common than those associated with invasion of muscle by the larvae, but when they occur they are found during the first week after infection. Diarrhea is seen in about 40% of patients in epidemics; the stools are of variable consistency and are sometimes blood-stained. Abdominal discomfort afflicts 20% and vomiting develops in 10% of cases. Patients with extremely heavy worm burdens may die from fulminant enteritis during this phase of the infection.

(2) **Eye and muscle manifestations.** Symptoms due to invasion of the muscles by larvae usually appear during the second week after infection, often around the 10th day. Fever is found in 90% of symptomatic patients, although it is variable in intensity and duration. Periorbital edema is usually the first physical sign, occurring in 80% of cases, and in severe infections may spread to other parts of the face; subconjunctival hemorrhages and chemosis also may be seen. Myalgia, often associated with muscle swelling and weakness, is seen in 80% of patients. It frequently begins in the extraocular muscles and then develops in the masseters, neck muscles, tongue, flexor muscles of the extremities, and lumbar muscles. Half of the patients complain of headache, and many have cough, shortness of breath, hoarseness, and dysphagia. A rash, often macular in nature, is seen in about 10% of subjects. Occasionally there are neurological or urological symptoms.

In most patients the symptoms reach a peak at two to three weeks of infection. Thereafter the fever abates and muscle symptoms slowly subside, but malaise and weakness may persist for weeks. Fatalities have been reported in about 2% of symptomatic patients; the usual cause of death is a nonspecific interstitial myocarditis (larvae do not encyst in cardiac muscle), but deaths are occasionally related to encephalitis or pneumonia.

**Diagnosis**

The process involved in the diagnosis of trichinosis is illustrated in the accompanying algorithm (figure 1). The infection may be suspected in a patient who presents with periorbital edema, myositis, and fever. At times, an otherwise asymptomatic patient may have eosinophilia. An epidemiological and dietary history should be taken, and if others who have eaten the same meat have similar symptoms, the likelihood of the diagnosis is greatly increased. The infection is unlikely if intensive questioning fails to elicit any history of eating the inadequately cooked meat of pigs or other carnivores (particu-
larly bears), but it must be remembered that some commercial beef products have pork additives.

The peripheral blood should then be examined for eosinophilia, which usually begins on about the 10th day after infection, is found in 90% of patients with clinical trichinosis, and sometimes reaches very high levels. If there is no eosinophilia, the diagnosis is less likely. Determinations of enzymes in serum may be useful indicators of muscle involvement. The level of creatine phosphokinase is elevated in half of the patients and the level of lactic dehydrogenase in somewhat more.

The skin test for *Trichinella* does not differentiate between past and recent infection, but serological tests (particularly bentonite flocculation) may be useful in establishment of the diagnosis. The advantage of this test is that titers of antibody fall to low levels within two years after infection, and thus the diagnosis of reinfection is facilitated. Unfortunately, levels of antibody are not detectable until three weeks after infection or longer, although 95% of subjects will eventually become positive; a titer of 1:5 or a fourfold rise in titer is considered to be of diagnostic significance [4]. This test is simple, rapid, and reproducible and may be purchased in kit form from Difco Laboratories (Detroit, Mich.). Alternatively, serum may be sent to the Center for Disease Control (Atlanta, Ga.).

If a patient has a positive epidemiological and
dietary history, eosinophilia, and positive serologic results, then the diagnosis is probable, and it is unnecessary to proceed to muscle biopsy. Doubt may be resolved by taking a biopsy specimen from a tender swollen muscle at least three weeks after the presumed onset of infection; by this means the chances of obtaining a positive result are increased because of increased numbers of larvae, their greater size, and large inflammatory reactions. In epidemics, the number of positive biopsy specimens has varied between 25% and 100% but is usually closer to the higher figure. If the biopsy specimen is positive, the diagnosis is confirmed.

Management

The treatment of trichinosis is unsatisfactory [5, 6]. Thiabendazole (Mintezole,® Merck, Sharpe and Dohme, West Point, Pa.) may eliminate intestinal worms if given within one day of ingestion of larvae. In rare instances, when there is a localized epidemic and a patient is known to have ingested trichinous meat recently, the drug should be administered in a dose of 25 mg/kg twice daily for one week. Usually, however, the diagnosis is not made until two weeks or more after infection. At this time, thiabendazole has no effect on the numbers of larvae in muscle, nor does it significantly alter the course of the disease. The mainstay of therapy is the administration of anti-inflammatory analgesic agents such as salicylates. Critically ill patients may be treated with corticosteroids, but the evidence for benefit is equivocal.

References