Control of trichinellosis by inspection and farm management practices

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Abstract

The prevention of human trichinellosis by proper meat inspection is a classic example of successful veterinary public health measures. The microscopic methods which have been used for more than a century to test pigs for trichinae were intended to prevent human disease. However, the value of these relatively insensitive direct detection methods, including trichinoscopy and pooled sample digestion, was debated as soon as more sensitive indirect (serological) methods became available. Two issues related to testing were discussed. First, should public health authorities endeavour to prevent all infections of humans rather than simply prevent the occurrence of disease, and second, would epidemiological surveillance and monitoring of the pig population on farms not provide a better control system to prevent human infection. This latter issue is of particular importance for those countries in the world where human trichinellosis acquired from farmed animals is absent and examination of pigs at the abattoir only results in negative findings. In countries where domestic pig infections are virtually non-existent, monitoring of Trichinella infection in wildlife could also contribute to understanding the infection pressure from nature to livestock. Trichinella-free pig farming is a feasible option for controlling this zoonosis, even in endemic areas. This approach provides an opportunity to combine good veterinary practice, in order to prevent animal diseases, with the prevention of Trichinella infection. All animals with access to the environment, or animals which are fed with potentially Trichinella-infected feed (swill, carcasses) will always constitute a public health threat, and must be inspected individually at slaughter (swine, horses, wild boars). Finally, it is important to recognize that trichinellosis is a world-wide problem that needs continuous public health attention. If no control system exists, for whatever reason, the public should be educated not to consume improperly cooked meat. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

One of the best examples of successful veterinary public health measures to prevent human disease is the abattoir control of *Trichinella* in pigs. After the recognition, in the 19th century, of *Trichinella spiralis* as a worm infection of people caused by eating infected pork, very effective methods were introduced to identify infected pigs immediately after slaughter. This discovery of the source of human trichinellosis and methods to detect the parasite in slaughtered animals, led to the first meat inspection measures regulated by legislation in many European countries. Initially, control at the abattoir was carried out by veterinarians using a trichinoscope (Zimmerman, 1983); more recently, many countries have switched to the more efficient artificial digestion methods (Forbes and Gajadhar, 1999).

Since the advent of testing, there has been international debate on the accuracy of the control methods employed, and the profitability of economic nationalism versus the requirement of sanitary measures to prevent human disease regarding free trade of pork and pork-products between countries (Hoy, 1989). Countries of the European Union inspect all pigs intended for interstate trade and some of these countries also require inspection of pigs intended for domestic consumption. The cost of this testing is enormous (US$ 570 million per year) (Pozio, 1998). In fact, most developed countries have some level of slaughter control for *Trichinella* in pigs. Among the developed countries, the United States does not test individual pigs at slaughter. This country has relied on processing methods and the cooking habits of the consumer to prevent human infection (Gamble, 1998a).

The facts that proper control requires expensive, large scale inspection systems, and that there is a good deal of private home slaughtering that is not subject to veterinary inspection are the two main reasons why trichinellosis is still a world-wide problem. Moreover, there are a variety of other and more complex reasons why trichinellosis is still not under control in many parts of the world. These reasons include: socio-economic changes, evolution in the food habits of people or new food habits associated with immigrants, new sources of infection (other than pork), and an increase in international trade and tourism (van Knapen, 1997). Economic problems, erosion or lack of veterinary infrastructure and the failure of educational systems in large parts of the world limit use of proper control measures at the farm level, effective use of abattoir control methods, dissemination of information to consumers, and an awareness of the disease by the medical profession.

In this review, control measures will be discussed against the background of available laboratory methods, policy decisions about objectives in the control of trichinellosis and endemicity of *Trichinella* infection in people and animals in specific geographical areas.

2. Detection methods

Methods to detect *Trichinella* infection in people or animals can be divided into two categories: direct methods that visually demonstrate the parasite in muscle tissue and indirect methods that suggest the presence of the parasite in a particular host based on an immunological response to parasite antigens. Examples of direct methods include trichinoscopy and a variety of artificial digestion methods using muscle samples from slaughtered animals. To optimize the efficiency of these tests, select sites such as diaphragm, tongue or musculi
extensor of the front legs, where larvae are found in higher numbers, are usually tested. The choice of predilection muscle varies with the host-species under examination and should be based on scientific data from experimental infection and search for the most infected muscles (Nöckler et al., 2000, loc. cit.; Kapel, 2000, loc. cit.).

Direct methods have limited sensitivity and often fail to detect even light infections. For example, the various pooled sample digestion methods using a 1 g sample size, have a sensitivity of approximately 3 larvae per gram (LPG) of tissue (Gamble, 1998a). The sensitivity of the trichinoscope varies according to how much muscle is examined (0.5–1.0 g), but typically is considered to have a sensitivity of 3–5 LPG.

Indirect methods such as serological tests (for a humoral immune response) or skin testing (for a cellular immune response) have the advantage of testing animals that are still alive. Furthermore, the sensitivity of many of these methods have the potential to be much greater than direct methods, allowing detection of infections as low as a few larvae in more than 100 g of predilection site musculature (Gamble et al., 1983). However, factors such as the quality of the reagents used and the standardization of the tests largely influence the reliability of indirect methods (Gamble et al., 1988; van Knapen et al., 1986). Serological tests have proven useful as a tool to confirm a supposed presumptive diagnosis of trichinellosis in humans and as screening (monitoring) tools to determine prevalence in a population of humans or animals (Ruitenberg et al., 1983). When a serological test is used at the individual level, sensitivity and specificity play major roles in the accuracy of the methods used; however, at the population level, predictive values (positive or negative) are the criteria to be assessed before methods can reliably be used. The latter criteria are directly related to the prevalence of *Trichinella* in the population under examination.

The methods and principles of both direct and indirect tests have been exhaustively described in the literature and in handbooks. International organizations have described specific methods in detail (EU Directives 77/96/EEC and 84/319/EEC; Gamble, 1998b) and have greatly contributed to consistent meat inspection regulations. Recent developments and debate on control measures are updated every 4 years in the proceedings of the scientific meetings of the International Commission on Trichinellosis (e.g. Ortega-Pierres et al., 1997). Here a variety of public health objectives are discussed in relation to existing and proposed control measures.

3. **Veterinary public health objectives**

3.1. Prevention of disease in people

After the recognition of *T. spiralis* as a human pathogen which could be detected in the musculature of infected pigs by relatively simple microscopic examination, regular inspection methods were introduced at the abattoir in most industrialized countries. With the introduction of trichinoscopy, it was shown that when routine slaughter inspection was practised human disease could largely be prevented. However, private slaughtering, without veterinary control, illegal slaughtering, cultural habits, or disbelief in parts of the world that trichinellosis is a preventable infection are some of the reasons why this disease has remained a public health problem in many countries. Sometimes, in areas with no tradition
of consuming improperly cooked pork (products) a public health problem was recognized only after the introduction of new eating habits or after the immigration of people from other cultures (Imperato et al., 1974).

The goals of the European directives on inspection of fresh meat are to prevent disease in people. Because only relatively heavily infected carcasses can be identified after applying routine direct methods to livestock inspection, it is undoubtedly true that low level infections have occurred as a result of eating ‘inspected’ meat. However, outbreaks of trichinellosis have been prevented by removing contaminated carcasses from the meat production process. The success of this approach in countries practising veterinary control has been manifested by the virtual eradication of *Trichinella* from domestic pigs.

### 3.2. Prevention of infection in people

The introduction of sensitive serological methods and extensive efforts to compare the efficacy of direct and indirect systems to prevent human disease, led to discussions as to whether meat should be completely free from parasites or whether the goal should be the prevention of disease in people. It has been concluded that while serological methods provide enhanced sensitivity, and would, therefore, detect additional animals harbouring low-level infections, existing indirect methods also suffer from a low rate of false-negative reactions. For the purposes of safeguarding human health, this is not an acceptable alternative. Therefore, existing direct detection technology has not been replaced by other methods. Considerations of the use of inspection methods have paralleled discussions on alternative methods for prevention of human trichinellosis using processing such as freezing or irradiation of carcasses as a method of decontamination (Steele and Engel, 1998).

Modern or industrialized systems of animal production have impacted control of *Trichinella*. The objectives of these modern systems for raising and fattening of pigs on a large scale, under high containment conditions, are to keep out infectious animal diseases and to produce standard quality, safe and wholesome food. Under these conditions, which reduce or eliminate all opportunities for transmission of *Trichinella* to pigs, trichinellosis has simply disappeared as a source of infection through pork.

### 3.3. Epidemiology versus individual carcass control

With the availability of reliable serological tools (Gamble et al., 1997) and the movement of the pork production industry to modern management systems, control procedures for *Trichinella* are being reassessed. Particularly in geographic areas where human trichinellosis is not reported and where abattoir control yields only negative results, it is questionable whether routine carcass control at the abattoir is still necessary. Sero-epidemiological monitoring programs have been established for a number of animal (pig) diseases in many countries already. Thus, it is reasonable to believe that monitoring the actual presence or absence of *Trichinella* infection in a pig population is feasible, in some countries, as an alternative to meat inspection.
Because the production cycle for pigs is very short, and the infection pressure from *Trichinella* in wildlife may exist permanently, even where domestic animals are not infected, a continuing monitoring program is preferred over regular interval surveillance. For such a program to be successful, proper identification and an administrative system would be required for all livestock in such areas. An epidemiological control system in a given area could be based on certification of herds/farms. This implies that the negative predictive value of the test system should be high (>99%), and therefore, the most sensitive serological methods should be employed (van Knapen, 1994). However, because of the infection pressures from *Trichinella* in wildlife, a monitoring program cannot absolutely guarantee against an accidental introduction of *Trichinella* into the certified herd.

4. Control systems

The International Commission on Trichinellosis has recognised since 1980 that the existing control methods are not infallible. Despite numerous improvements, this is still true today. Human error, accidents, and other factors will always allow for some low probability of infection. Development and use of proper quality assurance systems, including training, education of personnel, validated tests and control of critical control points are prerequisites for minimizing risks in any country (Forbes et al., 1998; Forbes and Gajadhar, 1999).

4.1. Control in endemic areas

In endemic areas, defined as areas where irregular outbreaks of trichinellosis are reported either as small family outbreaks or large scale, urban type outbreaks, it is obvious that continued meat inspection at the abattoir level is necessary. The prevention of human disease is the primary goal in this situation. Individual carcasses should be examined by methods with sensitivity at least as good as classical trichinoscopy. Generally, direct methods to demonstrate the absence of *Trichinella* larvae in pre-determined amounts of specific muscle are preferred as preventive measures. Since the recognition of *T. pseudospiralis* as a definite human pathogen (Jongwutiwes et al., 1998) the artificial digestion method might be considered as a better technique than trichinoscopy in *T. pseudospiralis* endemic areas. In endemic areas, serology is not acceptable for preventive control of carcasses at the abattoir level, since individual immunological responses may vary and infections may be detectable only after several weeks (4–6) depending on the initial infectious dose of the animal (van Knapen and Ruitenberg, 1985).

4.2. Control in non-endemic areas

Non-endemic areas are defined as geographically determined areas where human trichinellosis has not been reported for more than 10 years as a result of the consumption of meat (products) produced in that area. Despite the obvious absence of *Trichinella* in domestic pigs in these areas, legislation in many countries often still requires individual control at the abattoir, using relatively insensitive methods. Public health authorities in such areas would benefit from information on the prevalence of *Trichinella* infection in people and animals.
that can only be obtained by more sensitive methods (i.e. serology). Epidemiological surveys should be carried out using sufficiently sensitive methods before concluding that an area is free from Trichinella infection. Such surveys should include both people and animals such as livestock and carnivorous wildlife species such as wild boars, foxes, cats, martens, lynx, badgers, and bears.

In a particular region, indicator wildlife animal species may be identified (e.g. fox) which reflect the infection pressure in that area. If such indicator animals show no or limited T. spiralis infection (<0.1% of the population), individual control of slaughter pigs originating from modern farms should not be necessary (Pozio et al., 1996). Individual animal control may be replaced by monitoring of farms/herds, followed by certification of the absence of Trichinella infection in the farm.

Although a European proposal was put forward to recognize Trichinella-free areas (van Knapen and Ring, 1998) this approach needs further practical evaluation. The definition of a 'geographical area' as well as unauthorized transportation of pigs and other animals from one area to another creates new problems. Further legislation to control Trichinella-free farming may be more effective than defining Trichinella-free areas.

4.3. Trichinella-free farming

Under strict conditions, it is possible to guarantee Trichinella-free pig farming. It has been demonstrated that the domestic life cycle of Trichinella will not occur in modern farming systems based on the absence of risks for transmission to pigs (Pozio et al., 1996). Modern or industrialized farming employing hygienic measures and strict rules of good production practices (GPP) combined with good veterinary practices (GVP) will exclude the risk of transmitting Trichinella. The minimum standards for hygiene include

- animals are kept in barns which exclude rodents and wildlife;
- hygienic barriers are maintained for authorized people who enter the facility (e.g. change of clothes and boots, washing facilities in pre-entrance area);
- free entrance to farming areas is blocked (e.g. fences, canals) and the direct environment is kept free from rough vegetation;
- rodent and bird control programs are in place;
- a qualified (sterile) feed source is used;
- new animals are admitted to the farm only after proper certification of Trichinella freedom;
- no garbage dumps are in the vicinity of the farm.

Regular control by public or animal health authorities is required to maintain Trichinella-free status as mentioned above (van Knapen and Ring, 1998). Animals originating from farms or herds with Trichinella-free status do not require examination at the abattoir level.

5. Other sources of Trichinella infection in people

In recent decades, large outbreaks in Europe were reported after the consumption of infected horse meat (Dupouy-Camet, 1997). Wild boars, and occasionally other wild life species, are also sources of human trichinellosis. Animals that have access to the environment and/or potentially infected feed (swill, carcasses, etc.) will always constitute a potential
public health threat with regard to trichinellosis. Consequently such animals (swine, horses, wildlife) must undergo proper inspection at the individual level before they are declared suitable for human consumption.

6. Final remarks

Human trichinellosis is still a public health problem that cannot be ignored in any part of the world. Even in areas where the problem has been absent for many years, it may reoccur for a variety of reasons as mentioned in Section 1 of this review (Dupouy-Camet, 1999). Therefore, appropriate control for this zoonosis should always be maintained in all areas. It is recognized that in many parts of the world none of the existing methods of control are applied because of a lack of equipment, reagents or trained personnel. Education of the public on potential risks of consuming improperly controlled meat of any animal origin that is not properly cooked before consumption should be part of the alternative control of human trichinellosis.

References


