Trichinellosis among the human population in Vojvodina

J M Petrovic¹, J Z Prodanov-Radulovic¹ and S N Medic²

¹Scientific Veterinary Institute Novi Sad, Rumenacki put 20, 21 000 Novi Sad, Republic of Serbia
²Institute of Public Health of Vojvodina, Futoška 121, 21 000 Novi Sad, Serbia

E-mail: jelena@niv.ns.ac.rs

Abstract. The origin of the parasites of Trichinella species goes back to very ancient times – as far as the Paleozoic era, and the organism has been present in the territory of today’s Europe for millions of years. The first epidemic in the region of Serbia was reported in Zemun in 1923. Trichinellosis is the most important parasitic food borne disease in our country. In Vojvodina alone, 58 epidemic outbreaks were reported in the period 2015-2019 with 853 affected patients. The average incidence was 3.5 diseased individuals per 100 000 population. High morbidity and hospitalization rates and the occurrence of lethal outcomes qualifies trichinellosis as belonging to the category of relatively severe human diseases in Serbia. However, there are promising data indicating that implementation of relevant control measures and improvement of the awareness of the population have led to a statistically significant decrease in the number of diseased persons with trichinellosis in both Vojvodina and the entire country.

1. Introduction

The first trichinellosis epidemic in Zemun, Serbia, was confirmed in 1923, more than 70 years after the first identification of Trichinella species as a parasitic agent in London in 1835 and introduction of pork meat inspection in Germany in 1866. Several years before the epidemics in Zemun (in 1918), the infection of pigs imported from Serbia has been confirmed in slaughterhouses in Berlin [1]. Several decades then passed from the first identification until recognition of the importance of this zoonotic parasite and its inclusion into the food control protocols. Meat inspection for trichinellosis in Serbia started as late as 1950, and mandatory meat examination at industrial slaughterhouses was introduced in 1952. Legislation on the mandatory pig meat inspection at slaughter for private domestic consumption dates back to the 1970s.

The history of trichinellosis control in Serbia shows a close correlation with the development of agriculture, industry, and society as a whole. At the end of the 1980s, a period characterized by peak levels of industrial pig farming and the minimum share of domestic pig breeding in the total swine production. Trichinella was found in only 90 animals out of the 1.2 million pigs slaughtered at slaughterhouses [1]. The later period of intensive financial crisis was characterized by the collapse of big production companies and the increase of household pig production during the 1990s, resulting in massive epidemics with sometimes lethal outcomes.

The Law on Protection of the Population from Infectious Diseases [2] established rules for the control of trichinellosis in humans. Since 1966, trichinellosis has been categorized as a mandatory reported disease in Vojvodina. Ever since, the occurrence of the disease in humans has officially been recorded. Massive epidemics have occurred during the 1980s and 1990s (907 diseased individuals were reported in 1985) [3].

In this paper, we present the major epidemiological features of trichinellosis in Vojvodina as well as the potential causes of epidemics. During epidemic outbreaks in Vojvodina, the collection and processing of the data is performed in active collaboration between the Institute of Public Health of
Vojvodina and the Scientific Veterinary Institute Novi Sad. The data pertaining to the entire territory of Serbia were obtained from the official web sites of the Institute of Public Health of Serbia “Milan Jovanović Batut”.

2. Epidemiological characteristics of trichinellosis in Vojvodina

2.1. Incidence
The average annual trichinellosis incidence in Serbia during the past 14 years was 1.5 (Table 1). The incidence rate in Vojvodina was somewhat higher as compared with the rest of the country; however, the difference was not statistically significant. The highest incidence was recorded in Vojvodina in 2005. An obvious decreasing tendency in the country-level number of diseased humans (Table 1) has been established, predominantly resulting from an increased percentage of industrially grown pork in human diets. Compared with other diseases caused by parasitic foodborne pathogens (echinococcosis and toxoplasmosis), trichinellosis has by far the highest incidence among the human population [4].

| Year | Serbia | Central Serbia | Vojvodina |
|------|--------|----------------|-----------|
| 2005 | 4.5    | 1.1            | 13.6      |
| 2006 | 2.5    | 1.7            | 4.9       |
| 2007 | 2.4    | 2.2            | 2.8       |
| 2008 | 1.2    | 0.7            | 2.8       |
| 2009 | 0.7    | 0.1            | 2.2       |
| 2010 | 1.5    | 1.9            | 0.5       |
| 2011 | 1.7    | 1.1            | 3.5       |
| 2012 | 0.6    | 0.7            | 0.6       |
| 2013 | 1.3    | 0.5            | 3.6       |
| 2014 | 1.2    | 0.9            | 1.9       |
| 2015 | 1.1    | 0.5            | 2.8       |
| 2016 | 2.7    | 2.7            | 2.7       |
| 2017 | 0.2    | 0.0            | 0.3       |
| 2018 | 0.2    | 0.2            | 0.1       |
| 2019 | 0.4    | 0.2            | 0.9       |
| Average | 1.5 | 1.2 | 3.5 |
| SD\(^a\) | 1.2 | 0.8 | 3.3 |
| Minimum | 0.2 | 0 | 0.1 |
| Maximum | 4.5 | 2.7 | 13.6 |
| CV\(^b\) | 0.8 | 0.8 | 1.1 |
| Sc\(^c\) | -55 | -39 | -52 |
| Confidence factor | 99.7% | 97.1% | 99.5% |
| Incidence trend | Decreasing | Decreasing | Decreasing |

\(^a\) standard deviation, \(^b\) coefficient of variation, \(^c\) Mann-Kendall statistic

2.2. Outbreaks
During the past 14 years, on average, four epidemic outbreaks were reported in Vojvodina annually (Table 2). The majority of patients (83.2%) were reported during the epidemics. Commonly, such epidemics occur within a single family or amongst members of two or several related families. A correlation between the number of diseased patients and the number of epidemic outbreaks could not be established – in 2007, 55 diseased patients were reported in 10 epidemic outbreaks, whereas 103 diseased individuals were reported in only one epidemic outbreak in 2005.

*T. spiralis* is the most frequently identified species in domestic and wild pigs in Vojvodina. It is the only *Trichinella* species detected during autochthonous epidemics in Vojvodina [5]. *T. britovi* was
recently identified as a causative agent in a massive epidemic transmitted from the region of central Serbia to Vojvodina [6]. In neighboring countries, T. spiralis is also a dominant species, but epidemics associated with T. britovi and T. pseudospiralis have also been reported [7].

In Vojvodina, trichinellosis shows highly seasonal prevalence trends (p<0.0049) with case numbers peaking in the period from December to February (63.6%) [8]. Similar tendencies were found in other parts of Serbia [9]. The seasonal character of the disease is associated with the seasonal domestic slaughter of pigs by the end November and production of traditional meat products. Similar traditions and, hence, seasonal patterns are observed in neighboring Bulgaria and Romania, but also in China and Argentina [7, 10, 11, 12, 13].

Table 2. Outbreaks of trichinellosis in Vojvodina, 2005-2019

| Year | Number of patients | Number of outbreaks | Number of patients affected in outbreaks | Percentage (%) of patients affected in outbreaks |
|------|--------------------|---------------------|----------------------------------------|-----------------------------------------------|
| 2005 | 277                | 8                   | 277                                    | 100                                           |
| 2006 | 98                 | 6                   | 80                                     | 81.6                                         |
| 2007 | 57                 | 10                  | 55                                     | 96.5                                         |
| 2008 | 55                 | 4                   | 51                                     | 92.7                                         |
| 2009 | 44                 | 4                   | 43                                     | 97.7                                         |
| 2010 | 10                 | 2                   | 8                                     | 80.0                                         |
| 2011 | 69                 | 1                   | 67                                     | 97.7                                         |
| 2012 | 9                  | 1                   | 4                                     | 44.4                                         |
| 2013 | 69                 | 8                   | 49                                     | 71.0                                         |
| 2014 | 36                 | 1                   | 34                                     | 94.4                                         |
| 2015 | 53                 | 6                   | 42                                     | 98.1                                         |
| 2016 | 51                 | 4                   | 48                                     | 94.1                                         |
| 2017 | 6                  | 1                   | 6                                     | 100                                          |
| 2018 | 2                  | 0                   | 0                                     | 0.0                                          |
| SUM  | 853                | 58                  | 781                                    |                                               |
| Average | 56.9              | 3.9                 | 52.1                                  | 83.2                                         |
| SD*  | 67.0              | 3.1                 | 66.8                                  | 27.5                                         |
| Minimum | 2                  | 0                   | 0                                     |                                               |
| Maximum | 277                | 10                  | 277                                   | 100                                          |

* standard deviation

2.3. The structure of cases

Even though the majority of patients were males (60.2%), gender-related differences were not statistically significant (p = 0.37) [8]. In the majority of animals, parasitic diseases occur more commonly in male individuals, which is predominantly due to their behavior (aggression) and consumption of larger amounts of food. Testosterone has an immunosuppressive effect, thus increasing the susceptibility of male individuals to parasites, whereas progesterone shows antiparasitic effects. Exceptionally, male animals show higher resistance towards Plasmodium berghei, Trypanosoma cruzi and Strongyloides spp., yet not to Trichinella spp. Female sex hormones enhance immune response and lead to higher antibody levels and stronger adaptive immunity. Administration of stilbestrol (synthetic estrogen) to male rats results in significantly lower number of intramuscular larvae [14].
The vast majority of patients from Vojvodina are adults over 20 years of age (83.2%). Age-specific incidence varies from 9.5 (age 0-9) to 44.5 (age 40-49) per 100 000 population. It was confirmed the incidence of trichinellosis in children under 9 years of age is significantly lower than that in older age groups (p = 0.03-0.04) [8]. Considering the underdeveloped immune system in children, a more severe clinical manifestation of the disease would be expected in this population; however, trichinellosis disproves this hypothesis. The disease shows a milder clinical picture and a shorter course in children than in adults [15]. This is probably due to the fact that children consume lesser amounts of meat, especially traditional meat products that have a strong and salty taste. Moreover, the manifestation of allergic reactions in children is weaker as compared to other age categories [16].

2.4. Morbidity and mortality
The high infectivity of Trichinella for the human population is reflected by the high morbidity rate recorded in Vojvodina (12.0-100%). The morbidity is the ratio of number of diseased to the number of exposed individuals [8]. Hospitalization rates vary across Serbia according to regions and periods of data processing, ranging between 13.5 and 72.7%. A significantly higher hospitalization rates was established in Vojvodina (41.6±31.1%) as compared to the city of Belgrade (13.5%) [8,9]. These differences are more likely associated with hospitalization criteria rather than with the severity of the clinical picture.

During the past 14 years, three lethal outcomes of trichinellosis cases were reported in Serbia and all of them in the same year (2005) [3]. The primary cause of death in two cases was acute myocarditis and endocarditis, whereas the third case was an immunocompromised person who had already been hospitalized for another reason. In 2005, trichinellosis mortality rates (number of lethal outcomes to total population ratio) were 0.02 and 0.10 per 100 000 in Serbia and Vojvodina, respectively. The trichinellosis lethality rate (ratio of the number of deaths to number of diseased patients) was 0.8% in Serbia and 0.7% in Vojvodina. The mortality rate in Serbia (0.4%) was higher than the average mortality rate in 55 countries, where trichinellosis occurs autochthonously (0.2%) [17]. Long-term health effects among diseased individuals were reported only in infections associated with T. spiralis and T. murrelli [18].

Morbidity and hospitalization rates and the occurrence of lethal outcomes indicates that trichinellosis has to be considered relatively severe human disease in Serbia. The severity of the clinical picture is also associated with the fact that infections are most frequently caused by T. spiralis which is the most pathogenic of all Trichinella species for humans.

2.5. Incriminated food
The food that is considered as the most common cause of epidemics in Vojvodina, as well as in Romania and Bulgaria, is meat products originating from pigs from extensive farming. In Vojvodina, traditional meat products are associated with 54.9% of epidemic outbreaks as the only source of infection, and with an additional 23.5% of outbreaks as a mixed source with meat. Consumption of raw sausages for roasting originating from backyard pigs was identified as the cause of 5.9% of epidemics [8]. In spite of the variations between traditional meat products in the region (fermented sausages, products for grilling, dry meat products, charcuterie) their common feature was that they were produced in the household and underwent poor thermal processing [8, 13]. Traditional meat products considered a source of infection in Vojvodina include fermented and dry sausages, ham and raw sausages for roasting.

2.6. The sources of epidemic
In spite of the mandatory meat inspection in Serbia, the main underlying cause of the occurrence of massive epidemics in Vojvodina (103 diseased in 2005 and 48 cases in 2006) is the consumption of traditional meat products purchased from illegal production of uncontrolled meat. In 2011, the epidemics with 67 diseased individuals was related to an error during meat inspection (an unauthorized and untrained person performed the examination). In Vojvodina, the consumption of non-inspected pork meat is considered a major source of epidemic outbreaks, whether the meat originates directly from
backyard pigs (54.9%) or from illegal production of traditional products (33.3%). Errors during meat examination were identified as the cause of 11.8% epidemic outbreaks [8].

Major reasons for errors in meat examination included the following [6, 8]:

a) The meat was not examined,

b) The meat examination is performed by unqualified person,

c) An inadequate method was applied, e.g., examination of wild boar meat by compression method,

d) An inadequate sample was used, e.g., examination of intercostals muscle by compression method,

e) Examination was performed using an inadequate amount of the sample e.g., less than 10 g diaphragm from wild boar or less than 2 g diaphragm from domestic pig.

Errors in meat examination can occur and always result from non-adherence to standard procedures. In order to reduce the number of diseased individuals, it is essential to improve the knowledge and awareness of consumers and producers, and apply strict measures to prevent illegal trade of traditional meat products. Comprehensive control of all legal entities authorized for meat inspection should be included into the protocols and measures for disease control.

In spite of significant improvements of the awareness of the population and pig producers and development of the meat processing industry, the current epidemiological situation in Serbia strongly suggests that trichinellosis still remains one of the most important parasitic zoonoses. Such an ingloriously high rank is due to the severity of clinical trichinellosis illness and occurrence of lethal outcomes, as well as to the spread of human disease and animal infections across the entire country. Proper farming management is the cornerstone of infection control in animals. In Western European countries, more than 90% of pigs originate from intensive farming. Thus, human infections associated with consuming pork meat from domestic pigs are minimal. In Serbia, less than 5% of the total number of pigs is from intensive production, whereas the majority originates from backyard breeding or small- or medium-scale family farms. Backyard breeding is characterized by complete lack of relevant biosafety measures, while family farms apply such measures at highly limited levels.

3. Conclusions
Epidemic trichinellosis outbreaks in Serbia are largely influenced by illegal trading of traditional meat products. Considering that traditional products are highly valuable foods, their production must be maintained, yet under strict control. Modern Serbian legislation prescribes a range of relevant measures for quality control of traditional products in craft workshops. However, according to our research, the highest risk is associated with illegal domestic production and trade and consequent epidemics, which could affect and endanger consumers numbering in the hundreds.

Establishing continuous trichinellosis control relies on knowledge and awareness about proper disposal of infected animal carcasses and, importantly, on implementing appropriate biosafety measures in farming practices. The knowledge and experience in adequate meat examination as well as controlling of all legal entities authorized for meat examination are of vital importance.

The range of measures to be taken cannot ensure complete eradication of the infection in game animals. However, human infection could be eradicated, and Serbia could take a position as a country with developed, intensive pig production, preserved production of a variety of safe, traditional products, and healthy consumers.

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