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Meat-Borne Zoonotic Sarcocystosis: A Minireview about its Impact and Implications

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Mini Review

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Abstract

Sarcocystosis is a global parasitic entity with a significant economic impact on meat animals. Additionally, the condition is very zoonotic and affects human well-being. Lately, several species that don't harbour humans as definitive hosts are now known to affect humans with significant health impacts. The present mini-review comprises zoonotic sarcocystosis along with the miscellaneous species affecting humans. Their pathogenesis, forms, and presentations, along with the control strategies, are also described herewith.

Keywords: Humans; S*arcocystis* species; Zoonosis

Introduction

Sarcocystosis is a prevalent parasitic disease that affects a large number of animals worldwide [1-3]. The condition is attributed to the various species of apicomplexan parasites within the genus *Sarcocystis*. Levine initially examined the taxonomy of the numerous species within the *Sarcocystis* genus [1]. It infects many meat animals, such as sheep [4], goats [1], buffaloes [5-8], cattle [9-11], among others. The Sarcocystidae family consists of heterogenous apicomplexan parasites, exhibiting a mandatory two-host life cycle involving a predator and prey relationship. The parasite produces oocysts within the intestinal lining of its definitive host following the sexual phase. Within the intermediate host, the parasite undergoes asexual reproduction, forming schizonts in vascular endothelial cells and sarcocysts in striated muscle cells [1]. Consumption of muscle tissues containing sarcocysts infects the definitive hosts, whereas ingestion of oocysts or sporocysts found in contaminated food or water sources is associated with infection in the intermediate hosts. Sarcocystosis typically presents as a hidden or concealed infection because the clinical symptoms are nonspecific. Diagnosing the disease in live intermediate hosts is challenging since no parasitic stages emerge from these hosts [1,5]. The condition is commonly identified during post-mortem examinations when the tissues of slaughtered or deceased animals undergo macroscopic and microscopic inspections [5,10].

Underlying the Causative Aetiology

Among the various *Sarcocystis* species, three of them have a life cycle involving various animals and humans as their intermediate and definitive hosts, respectively [12-14] (Figure 1). These species are *S. hominis, S. heydorni*, and *S. suihominis* [1,12]. Humans can also become infected and ill from consuming raw, contaminated meat. Meat containing *Sarcocystis* spp. infections are not safe for human consumption, as they can result in a range of health

issues such as diarrhea, bloating, difficulty breathing, rapid heartbeat, nausea, and decreased appetite [13,14]. In India, cases of severe abdominal pain and diarrhea in infected persons are associated with the consumption of offal contaminated [1]. Hence, the repercussions of sarcocystosis in the meat industry are often significant.

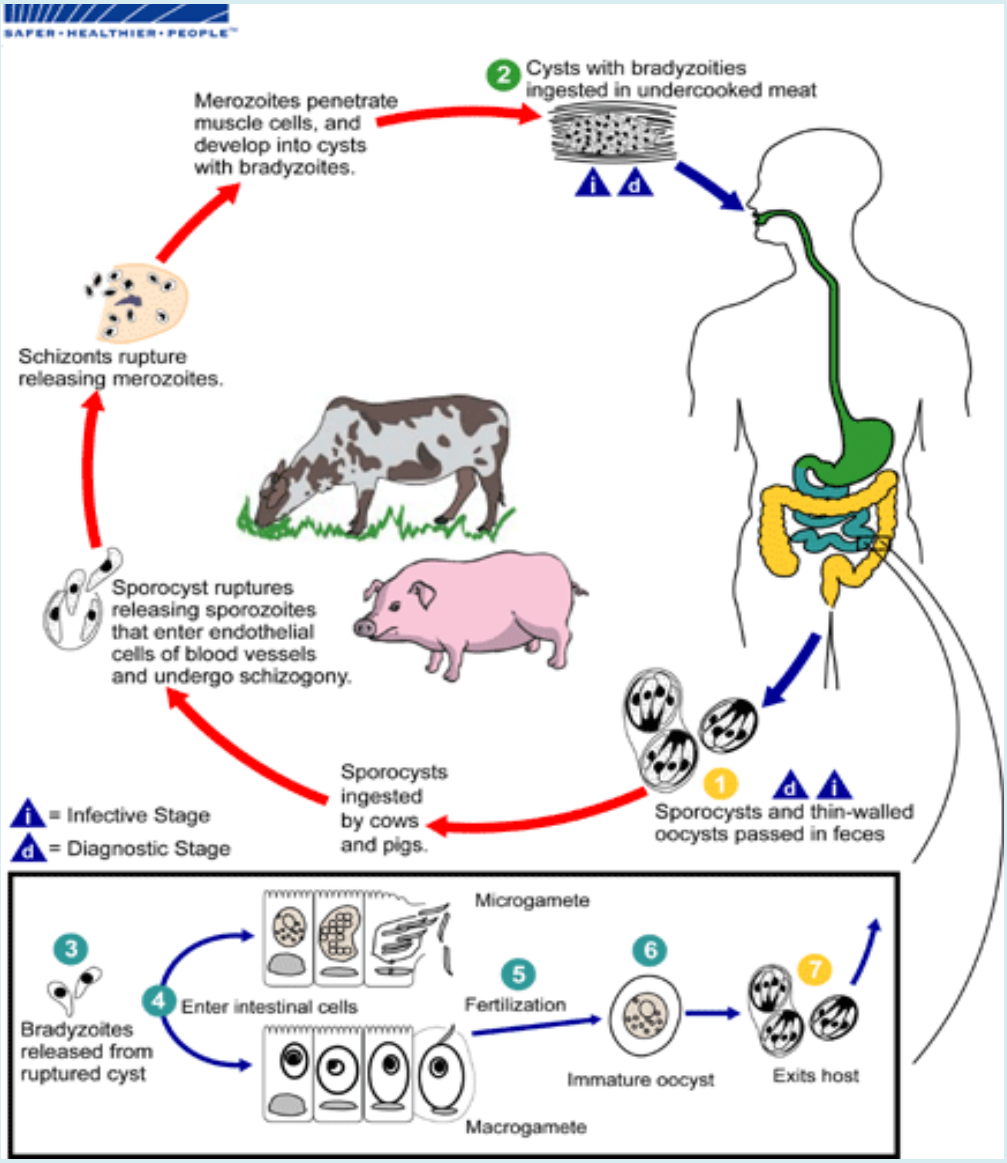

Figure 1: Life cycle of Sarcocystis species with humans as definitive hosts. [From Centre for Diseases Prevention and Control (CDC) site, https://www.cdc.gov/dpdx/sarcocystosis/index.html].

Inadequately cooked beef containing sarcocysts can lead humans to become definitive hosts for *S. hominis* [15] or *S. heydorni* [12]. *S. hominis* is recognized for forming sturdy-walled cysts in cattle tissue, particularly in heart muscle whereas *S. heydorni* produces thin-walled cysts with distinctive short protrusions from the cyst wall [1,16]. Conversely, consumption of undercooked pork meat could result in infections with *S. suihominis* [17].

The Curious Case of *Sarcocystis nesbitti*

Sarcocystis nesbitti, initially identified in tissue cysts within *Rhesus macaques* [18], was identified as the causative agent behind several human outbreaks, with predatory snakes serving as its definitive hosts [19]. The first documented cluster outbreak of symptomatic muscular sarcocystosis occurred among six American military personnel participating in a

jungle mission in Malaysia [20]. However, the most significant outbreak involved 89 symptomatic patients infected with *S. nesbitti* in Malaysia [20]. This outbreak affected foreign nationals who, between 2011 and 2012, returned from Tioman Island, which is located off the eastern coast of Peninsular Malaysia, and occasionally developed an acute muscular illness similar to the Sarcocystis infection [20].

Reports of Zoonotic Sarcocystosis

The existing literature on human sarcocystosis primarily consists of individual case reports and sporadic outbreaks originating from regions like Southeast Asia, Malaysia, and Thailand [1]. Limited seroprevalence studies and stool surveys conducted in these areas corroborate the widespread presence of this condition and human exposure to it [12,21]. Autopsy examinations conducted in these endemic regions have unintentionally revealed frequent occurrences of widespread human infections. For example, in one autopsy study, the estimated prevalence of infection surpassed 20% [21].

In Iran, *Sarcocystis* sporocysts were identified in humans (> 2000 cases) with unexplained abdominal discomfort [22]. Studies on the pathology of human sarcocystosis are limited to research conducted on human volunteers intentionally infected with what could be considered unusually high quantities of sarcocysts. Moreover, the complete genome of *S. neurona* is an ideal model for studying the biology and pathogenesis of the condition [23]. Additionally, a toxin derived from *S. fayeri* is the cause of food poisoning in individuals who consume raw horsemeat [24].

Forms of Zoonotic Sarcocystosis

The classical forms of zoonotic sarcocystosis are well described in the literature alongside standard textbooks [1]. The clinical presentation of human sarcocystosis can be categorized into two forms. The first form is the enteric form, where most individuals with intestinal sarcocystosis do not exhibit any symptoms. However, in cases of experimental infections, there are signs of abdominal discomfort, nausea, and self-limiting diarrhoea. The severity of these symptoms tends to correlate with the quantity of meat consumed [13]. Diarrhoea usually begins suddenly and typically resolves within 36 hours. The second form is a muscular infection, and like gastrointestinal infections, cases of extraintestinal sarcocystosis typically do not present with cardinal symptoms [1,12].

Atypical Presentation of *S. nesbiti*

During an outbreak of eosinophilic myositis within a U.S. military unit deployed in Malaysia, 7 out of 10 individuals exposed reported an acute illness characterized by fever, muscle pain, bronchospasm, temporary itchy rashes, passing swelling of lymph nodes, and nodules under the skin [18,20]. Increased eosinophils, a higher erythrocyte sedimentation rate, elevated hepatic enzymes, and increased muscle creatinine kinase were reported. In a recent occurrence of sarcocystosis on Tioman Island, Malaysia, which affected 93 individuals suspected of the disease, two cases were confirmed to have tissue cysts of *S. nesbitti* [20]. Common symptoms observed among the affected individuals encompass elevated body temperature, muscle discomfort, and coughing [20]. Individuals with symptoms might also experience painful muscle swelling, typically measuring 1 to 3 cm in diameter, initially accompanied by redness of the skin above the affected area. These episodes can occur intermittently and last from 2 days to 4 weeks. Few instances are accompanied by fever, generalized muscle pain, muscle tenderness, weakness, elevated eosinophil levels, and bronchospasm [18,20].

General Preventive Guidelines

The preventive measures outlined in the literature Dubey JP, et al. [1,12] provide detailed guidance for averting sarcocystosis in humans. It is imperative to ensure thorough cooking or freezing of meat to eradicate bradyzoites [1]. Moreover, cooking effectively neutralizes any potential toxins associated with sarcocyst ingestion [1]. While meat inspection may aid in reducing certain infections, it is a costly and time-consuming endeavour, requiring the identification of these organisms within the meat. Detecting sarcocysts through microscopic or antibody-based methods can be challenging unless the infection is severe [5]. Additionally, these tests may not offer insight into the specific species involved, thereby raising confusion if the species are not of any zoonotic potential. To prevent enteric infections, it is advisable to refrain from consuming improperly cooked or raw beef and pork. Sarcocysts present in pork can be effectively eliminated by subjecting the meat to temperatures of 60°C for 20 minutes, 70°C for 15 minutes, or 100°C for 5 minutes [1]. Freezing pork at -4°C for 2 days or -20°C for 24 hours can also achieve the same result. However, sporocysts and oocysts are more resilient; they can be destroyed by heating to 60°C for 1 minute, 55°C for 15 minutes, or 50°C for one hour, but they can withstand freezing [1,12].

To prevent the infection of domesticated food animals, it is critical to ensure that human faeces containing sporocysts do not contaminate water sources, bedding, or animal feed. Sanitation practices, including toilets and thorough handwashing, are pivotal in reducing or eliminating contamination. Additionally, to prevent the ingestion of sporocysts, when drinking water is suspected to carry sporocysts, boiling is recommended as a preventive measure.

Filters can effectively eliminate sporocysts of *Sarcocystis* spp. [12]. It's important to note that chemical disinfection with chlorine or other agents is ineffective in killing *Sarcocystis* species. sporocysts [1,25]. Popular disinfectants such as 1% iodine, 10% formalin, 12% phenol, and 2% chlorhexidine do not effectively eliminate *S. neurona* sporocysts. However, a 5.25% solution of sodium hydroxide, commonly known as bleach, is sufficient for this purpose [26].

Conclusory Remarks

The full extent of the public health impact of human sarcocystosis remains uncertain. Although veterinary data indicate that immune suppression is a clinical risk factor for sarcocystosis, similar to toxoplasmosis caused by a closely related zoonotic parasite, such as conditions like pregnancy and AIDS, our understanding of how susceptibility to sarcocystosis may vary across different human populations is limited. The true prevalence of infection remains unclear. Alongside, the true picture of pathogenesis is also a bit unclear.

Conflict of Interest

None of the authors have any conflicts of interest.

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