

Advances of schistosomiasis control in China

Teng Zhao*

College of Plant Protection, Southwest University, Chongqing, China

*Corresponding author: zt657570896@email.swu.edu.cn

Abstract. China was once a heavily affected area of schistosomiasis, with an epidemic history of more than 2000 years. After the founding of the people's Republic of China, the incidence rate of schistosomiasis in China has significantly decreased after decades of continuous improvement of prevention and control methods and efforts of various parties. This paper summarizes the methods of schistosomiasis control in China, and hopes to provide some help for schistosomiasis control in the world.

Keywords: Schistosomiasis, detection technique, snail control, domestic animal host.

1. Introduction

Schistosomiasis is an infectious disease caused by human infection with *Schistosoma japonicum*. According to the different responses of human immune system, the incidence rate of schistosomiasis can be divided into acute type and chronic type. The acute type is often accompanied by fever, abdominal pain and other symptoms. The chronic type is mainly organ damage. Since the symptoms of schistosomiasis are similar to those of other diseases such as diarrhea, schistosomiasis is usually regarded as other diseases and leads to disease deterioration. According to who statistics, among parasitic diseases, schistosomiasis is second only to malaria in disease burden. It is estimated that by 2020, about 800 million people will live in schistosomiasis endemic areas, and about 241 million people will need treatment. Although schistosomiasis spreads widely in the world, the harm caused is very serious. However, the actual global disease burden caused by schistosomiasis is still greatly underestimated.

There are mainly three kinds of *Schistosoma* that infect human body and cause harm to human body, namely, *Schistosoma mansoni*, *Schistosoma japonicum* and *Schistosoma aegypti*. Among them, the disease caused by *Schistosoma japonicum* infection is the most serious and difficult to control. Due to the wide spread and great impact of schistosomiasis in the world, in February 2022, who issued the World Health Organization guidelines for the control and elimination of human schistosomiasis, aiming to provide evidence-based recommendations for countries to control the incidence rate of schistosomiasis, eliminate it as a public health problem and finally achieve transmission interruption. As one of the countries once seriously harmed by schistosomiasis, in the decades since the founding of new China, China has continuously developed through various efforts and technical means. The incidence rate of schistosomiasis has been greatly reduced, and the goal of eliminating the impact of schistosomiasis has been basically achieved [1].

Schistosomiasis also has a long history of prevalence in China. According to records, schistosomiasis has an epidemic history of at least 2100 years in China. Among them, schistosomiasis japonica is the main disease. At the beginning of the founding of the people's Republic of China, there was a lack of understanding of schistosomiasis japonica and a lack of systematic prevention and control planning. Therefore, the area south of the Yangtze River has been seriously damaged by *Schistosoma japonicum*. According to statistics, in 1948, the number of schistosomiasis patients in China reached 32.8 million, and there were many "uninhabited villages", "widow villages" and "big belly villages". As schistosomiasis is very serious, the state attaches great importance to the prevention and treatment of schistosomiasis [2]. In view of the seriousness of the schistosomiasis epidemic, China launched the national schistosomiasis control plan in the early 1950s. After more than 60 years of scientific prevention and comprehensive treatment, China has made great achievements in schistosomiasis control. In 2015, China reached the standard of schistosomiasis

transmission control, with the incidence rate lower than 3.3%; By the end of 2017, 50.89% of the 450 schistosomiasis endemic counties (cities and districts) in China had met the elimination standard, and 30.89% met the transmission blocking standard [3]. By the end of 2018, 58.44% of the 430 schistosomiasis endemic counties (cities and districts) in China had reached the elimination standard [4]. By the end of 2019, the proportion of 450 schistosomiasis endemic counties (cities and districts) that have reached the elimination goal will increase to 66.89% [5]. By the end of 2020, the proportion of the 450 schistosomiasis endemic counties (cities and districts) that have reached the elimination target will increase to 74.89% [6]. According to the data analysis in recent years, China is moving towards the stage of eliminating schistosomiasis, and has achieved effective control and elimination of the harm of schistosomiasis by the end of 2020, and has set the goal of eliminating schistosomiasis by 2030.

In the process of controlling schistosomiasis, China has mastered a series of appropriate technologies. Appropriate technology refers to a simple, easy to operate, economic, effective and applicable technology that can solve the practical problems of grass-roots prevention and control. Schistosomiasis often occurs in rural areas. Due to the limitations of medical conditions and detection conditions, some complex detection methods are difficult to popularize and apply. Therefore, in the process of eliminating schistosomiasis, a large number of scientific researchers in China have developed many suitable technologies, which have been or will be applied to this field. These technologies will provide the latest technical support for the eradication of schistosomiasis in China. In addition, some suitable technologies have been extended to schistosomiasis endemic areas in Africa and Southeast Asia, providing China's experience and wisdom for the global eradication of schistosomiasis. In this paper, the latest research progress of appropriate techniques for schistosomiasis control in recent years was reviewed.

2. Organization of the Text

2.1. Detection and control of *Schistosoma japonicum*

2.1.1 Detection of *Schistosoma japonicum* infected snails

Among the detection methods of snail *Schistosoma*, extrusion method and escape larva method are usually used to detect infected snail, but the two methods have a high rate of missed detection in low endemic areas. In addition, the crushing method needs to be identified one by one, which is time-consuming and laborious, unable to achieve batch detection and low efficiency; Although the escape larva method can realize population detection, the detection rate is low. Therefore, schistosomiasis control researchers have improved the traditional methods and tried to use molecular biology technology to achieve rapid detection of infectious snails. Improved breaking escape method. Wang Jiasong et al. Combined and improved the traditional crushing method and escape method, and established an improved crushing escape method for detecting infected snails [7]. The results of double-blind control experiment using crushing method as colloidal gold standard showed that the detection rate of the improved crushing method was 100%, 18.2 times as high as that of the crushing method and 17.3 times as high as that of the escape method. It is suitable for the detection of large-scale infectious snails. 18600 snails were randomly divided into 186 samples, which were detected by fragmentation method, escape cysticercus method and improved fragmentation escape cysticercus method. The results showed that the total coincidence rate between the pulverization method and the improved pulverization method was 100%, and the total coincidence rate between the pulverization method and the escaping cysticercus method was 98.92%; The detection efficiency of extrusion method, escape larva method and improved extrusion escape larva method were 1.58, 12.95 and 13.02 pieces / min, respectively. The field application results showed that the coincidence rate between the improved method of breaking and escaping larvae and the method of breaking was 100%. There was no statistical difference between the two methods in the detection rate of infected snail villages (25.79% and 28.46%; $\chi^2 = 1.079$, $P > 0.05$). The detection rate of infected spirals in the improved method of

breaking and escaping larvae was significantly higher than that in the broken method (5.57% and 3.66%; $\chi^2 = 95.464$, $P < 0.01$). Compared with the crushing method, the improved crushing method reduces the labor input by 87.86%, and saves 12.95 people per township (town). These laboratory test results and field application results show that the improved method is simple, accurate and labor-saving. It is suitable for the field batch detection of infected snails and the determination of the environment of infected snails in epidemic areas [8].

Secondly, in order to detect the infection of *Schistosoma japonicum* more accurately, the researchers used the isothermal amplification fluorescence method of nucleic acid mediated by recombinase. The snail samples were divided into 3 groups, with 7 subgroups in each group, of which 6 subgroups were 1, 2, 3, 4, 5 and 10 infected snail of *Schistosoma japonicum* mixed with 50 negative snail, and 1 subgroup was mixed with 1 infected snail and 100 negative snail. The three groups of snails were treated by the method of broken shelling nucleic acid kit extraction, broken shelling RNA rough extraction and direct broken shelling DNA rough extraction, and were detected by fluorescent RAA and PCR, and the detection results were compared [9]. The results of laboratory tests showed that this method could detect one snail infected with *Schistosoma japonicum* and distinguish it from 100 negative snails. According to the experimental results, the fluorescence method of isothermal amplification of nucleic acid mediated by recombinase is more sensitive than the traditional PCR method. The detection can be completed within 30 minutes and the operation is simple. A fluorescence RAA method for rapid detection of *Schistosoma japonicum* infected snails in snails was successfully established. The method is rapid, sensitive and easy to operate;

2.1.2 Molluscicidal technique

Oncomelania is the only intermediate host of *Schistosoma japonicum*. Snail control is one of the important measures to block and eliminate the transmission of schistosomiasis. Since the implementation of the schistosomiasis control plan in the 1950s, snail control has been an important part of the comprehensive schistosomiasis control strategy in China. In the early stage of schistosomiasis control, China mainly blocked the spread of schistosomiasis by using chemical agents to kill snails in water areas. However, in recent years, with the increasing attention of the state to ecological environment protection, the traditional snail control measures have been gradually abandoned due to their great harm to water bodies and aquatic organisms [10]. Therefore, the new ecological and environmental protection snail control technology is a priority topic in the field of schistosomiasis control in China. In recent years, Chinese schistosomiasis control workers have formulated some new snail control strategies and achieved good results.

As the national control measures for chemical drugs are becoming more and more strict. And the widely used chemical agents to kill snails have caused great damage to the water body and aquatic organisms in the process of use. In order to protect the environment and comply with the policy requirements. It is more important to find a way to control the snail population by ecological means. To this end, the south to North Water Transfer project team has developed the technology of protecting reed sand and burying snail. The technology of protecting reed sand to bury and kill snails is a new ecological snail killing technology. It is to cut reed grass (leave reed stubble) on the beach surface during the reed harvest season, and cover the beach surface with 20 cm thick river sand after leveling. Field observation shows that after treatment with this method. The mortality of *Oncomelania* was positively correlated with time. Under the constant temperature of 25 °C in the laboratory, the mortality rate of 3-month snails was 96.00%, and that of 6-month snails was 100%. In actual operation, after the flood season, the density of live snails increased by 100% compared with that before snail killing, and the density of live snails in the spring of the third year was still only 0.37 / 0.1m², achieving the purpose of reducing the density of *Oncomelania* and effectively inhibiting the transmission of *Schistosoma* [11]. Moreover, the reed grass grows well in the spring of the next year after sand burial, so it can be seen that this method has little impact on the ecology and meets the basic requirements of ecological protection.

2.1.3 Detection of *Schistosoma japonicum* infection

With the progress of schistosomiasis control in China, the epidemic area has shown a trend of low infection rate and low infection degree. With the reduction of the incidence rate of schistosomiasis, and the symptoms of schistosomiasis are similar to those of some common diseases. Therefore, higher requirements are put forward for the detection of schistosomiasis in the population. Accurate identification of schistosomiasis infected persons is the premise of accurate intervention. However, the traditional fecal examination methods and immunological diagnosis techniques have been unable to meet the needs of field control of schistosomiasis in the eradication stage. Therefore, the development of a sensitive, specific, convenient and rapid diagnostic tool for schistosomiasis is an important issue to be solved in the eradication of schistosomiasis in China.

A dynamic video automatic identification system of *Schistosoma japonicum* was developed by using optical, computer, digital and mechanical technologies and principles. The system can automatically identify *Schistosoma japonicum*. The coincidence rate of water worm detection and artificial observation was 100%, and that of water worm detection and artificial observation was 96.67%. Further studies showed that the accuracy of this instrument in detecting positive samples of *Schistosoma cysticercus* was significantly higher than that of manual observation (98.00% and 79.75%, $P < 0.01$), while the positive missed detection rate (2.22% and 35.56%, $P < 0.01$) and the false detection rate (1.82% and 7.73%, $P < 0.01$), and the time for detecting positive samples was only 50% of that of manual observation. As a reliable alternative to manual observation, this instrument has been widely used in the field diagnosis of schistosomiasis endemic areas in China[12].

2.1.4 Detection of *Schistosoma japonicum* infection in domestic animals

Epidemiological investigation shows that cattle and sheep are the main infectious sources of schistosomiasis in China. Fecal cercariae incubation method is the most commonly used method for monitoring and diagnosing schistosomiasis in livestock in China, and is also the colloidal gold standard for diagnosing *Schistosoma japonicum* infection in livestock; However, the infection rate and degree of *Schistosoma japonicum* in domestic animals in endemic areas are decreasing, and this method takes a long time. Therefore, this method can not meet the needs of field control [13]. Immunological diagnosis technology has the advantages of high sensitivity, convenience and rapidity. The researchers have successively developed serum immunologic diagnostic tools such as indirect hemagglutination test (IHA), enzyme-linked immunosorbent assay (ELISA), colloidal gold immunochromatographic strip (GICA) for the auxiliary diagnosis and screening of domestic animals. However, the false-positive rate of immunodiagnostic techniques is high and the specificity of field detection is low. Therefore, most schistosomiasis control personnel in China have established molecular detection techniques to achieve sensitive and specific detection of schistosomiasis infection in domestic animals at the elimination stage [14].

The researchers established a nested PCR technique targeting 231 BP DNA fragment of adult *Schistosoma japonicum* to detect *Schistosoma* infection in domestic animals. This technique can detect the specific DNA fragments of *Schistosoma japonicum* in the dried blood samples and serum of buffalo and sheep 7-28 days after infection, and detect the specific DNA fragments of *Schistosoma japonicum* at 14 and 28 days after infection. The sensitivity and specificity of bovine filter paper dry blood samples were 92.30% and 100%, respectively; The positive rates of buffalo and sheep filter paper dry blood samples in Dongzhi County, Anhui Province were 6.0% and 22.0% respectively, and the positive rates of buffalo filter paper dry blood and sheep filter cloth dry blood samples in Wangjiang County, Anhui Province were 8.0% and 16.7% respectively, which were statistically significant ($P < 0.05$). He et al. Established a real-time quantitative PCR technique based on mitochondrial NADH dehydrogenase subunit I gene. The infection rate of *Schistosoma japonicum* in farm cattle and buffalo in Hunan, Hubei, Jiangxi and Anhui provinces was significantly higher than that in fecal *cysticercus* hatching (24.73% and 7.69%, $P < 0.05$); The sensitivity of detecting *Schistosoma* infection in farm cattle and buffalo was significantly higher than that of fecal *cysticercus* hatching (96.83% and 30.43%, $P < 0.05$), and the specificity was 100%. These results indicate that

PCR is an on-site diagnostic and monitoring tool suitable for eliminating schistosomiasis infection in domestic animals at the stage of low prevalence of schistosomiasis [15].

3. Conclusion

China is moving towards the stage of eliminating schistosomiasis. Under the new situation, the work of eliminating schistosomiasis needs more precise intervention measures, such as snail eradication, identification of infectious snails, identification of infectious sources, chemotherapy and health education. In this paper, several suitable technologies applied in the field eradication of schistosomiasis in China in recent years, such as identification of *Schistosoma japonicum* infected snails, snail control, detection of human *Schistosoma japonicum* infection and information technology, are reviewed, which can provide reference for formulating schistosomiasis control strategies and selecting schistosomiasis control tools in schistosomiasis endemic areas in China.

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