Preplanned Studies

Reducing Canine Echinococcus Infection with Smart Deworming Collars — Tibet, China, June–November, 2020

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Summary

What is already known about this topic?

Existing manual deworming programs launched have made great progress in reducing the *Echinococcus* infection rate of domestic dogs, but significant challenges remain in scattered nomadic communities inhabiting the Tibetan Plateau. The low deworming frequency and low levels of coverage were responsible for the high infection rate of *Echinococcus* spp. among dogs.

What is added by this report?

Smart deworming collars controlled by a remote management system (RMS) was found to increase the deworming frequency and coverage and subsequently reduce the canine infection rates with *Echinococcus* spp..

What are the implications for public health practice?

As an innovative tool, smart deworming collars may drive the paradigm shift from manual deworming to smart deworming and stop the transmission of echinococcosis.

Endemic echinococcosis is still a serious challenge in northwestern China. We employed smart deworming collars controlled by remote management system (RMS) to deliver baits containing praziquantel (PZQ), a medication used to treat parasitic worm infections, for dogs. Compared with existing manual deworming techniques, the deworming coverage increased from 57.7% (173/300) to 85.7% (945/1,103) following the smart collars implementation, and the monthly deworming rate increased from 40.3% (121/300) to 91.4% (1,008/1,103). The positive rates of *Echinococcus* antigen in canine feces were reduced to zero, which suggests that this may be a novel effective alternative to reduce the transmission of echinococcosis.

Echinococcosis is a severe cross-species transmitted parasitic disease (*1*), and cystic echinococcosis (CE) caused by *Echinococcus granulosus* and alveolar echinococcosis (AE) caused by *Echinococcus. multilocularis* are the two main forms in human. In China, CE is widely endemic in at least 368 counties of 9 provincial-level administrative divisions (PLADs) and AE is co-endemic with CE in 115 of these counties (*2*). China remains the region with the most serious endemic disease burden, which comprised 40% of the world's CE disability-adjusted life years (DALYs) and 91% of new cases of AE per year globally (*3*–*4*).

Existing studies demonstrated that dogs were the most definitive host for *Echinococcus* spp. and its role in transmission of both CE and AE was significant (*5*). Periodic deworming of dogs is a highly effective measure against echinococcosis recommended by the World Health Organization (WHO) and Office International Des Epizooties (OIE) (*6*). In China from 2006, a monthly deworming program was employed to control the transmission of canine echinococcosis to livestock and humans (*7*–*8*), and significant progress has taken place to reduce the population prevalence of echinococcosis and the infection rate of *Echinococcus* spp. in dogs(*2*). However, in harsh climate and high altitude areas such as the Qinghai-Tibet Plateau, the unique humanistic values and nomadic production methods caused the implementation of manual monthly deworming for every dog encountered to become difficult and challenging, and the real data on the deworming coverage and frequency was difficult to obtain. Even in a county where the National Control Program struggled to achieve monthly deworming from 2010, the deworming coverage for dogs was not higher than 63.2% (*9*). In another county earmarked for the comprehensive control of echinococcosis in 2016–2017, only 21.7% (30/138) of dog owners performed deworming once a month (*10*). The low deworming frequency and coverage was responsible for the high prevalence of echinococcus among dogs, including 2.96% in Sichuan, 3.03% in Ningxia, 4.91% in Gansu, 7.3% in Xizang (Tibet), 13.0% in Qinghai, and 41.3% in Hobukesar County, Xinjiang, China (*2*,*9*).

In this study, we employed a smart deworming collar controlled by RMS, a platform specially developed for managing and controlling smart deworming devices, to deliver bait containing PZQ (100 mg per bait; Beijing Zhongnong Warwick Pharmaceutical Co., Ltd., Beijing, China. batch: 20190613) for dogs automatically, regularly, and quantitatively to increase the deworming frequency and coverage, reduce the dogs' infection rate of *Echinococcus*, further reduce the abundance of parasitic eggs in the environment, and ultimately prevent the transmission of echinococcosis from dogs to humans and livestock.

From June to November, 2020, a six-month field evaluation was performed in Kangma County, Shigatse City, Tibet Autonomous Region of China, which is a semi-agricultural and semi-pastoral border county with a severe epidemic of echinococcosis, an average altitude of >4,300 m, and an annual average temperature of about 4 °C. The population is around 34,000, of which >99% are ethnic Tibetans, the population prevalence of echinococcosis is 1.74%, and the overall positive rates of *Echinococcus* antigen in canine feces is 7.5%. Based on the production style, the population prevalence of echinococcosis, the number of dogs, and the positive rates of *Echinococcus* antigen in canine feces, a stratified cluster sampling method was conducted, and 5 townships were identified as smart collar group with 1,103 registered dogs and the other 4 townships as manual deworming group with 605 registered dogs. Local staff attached the smart deworming collars to all the dogs in the smart collar group according to the product specifications. The steps for attaching the smart collar to the dogs were as follows: 1) matching the information of the dogs, the owners, and the smart collars and uploading the information to the RMS; 2) set deworming frequency such as once a month, once a quarter, even once every six months according to the local prevalence of echinococcosis; 3) set the PZQ baits dose for each dog according to the dog's weight and size; and 4) set deworming time (8:00 or 18:00 on the deworming date), and then the smart deworming collar will run according to the set procedure. The dogs in the manual deworming group remained to be dewormed by the existing manual deworming methods.

In the smart deworming group, the deworming coverage and frequency of the smart collars were counted by the RMS. In the manual deworming group, due to remote locations of nomadic settlements, 300 dog owners (their dogs were randomly selected to collect dog feces once a quarter) were surveyed through questionnaires to obtain the information of monthly deworming. The total fecal sample size was estimated by the Walters normal approximation method and determined to be 600 (300∶300). Each quarter, 300 dogs were randomly selected from the 1,103-dog category and the other 300 dogs from 605-dog category by an accurate random sampling method followed by collection of the fecal samples from each of the chosen dogs. The fecal samples were tested once a quarter with the coproantigen ELISA Kit for Canines (produced by Shenzhen Combined Biotech Co., Ltd., Shenzhen, China) in the National Health Commission (NHC) Key Laboratory of Echinococcosis Prevention and Control. IBM SPSS (version 20.00; International Business Machines Corporation, New York, USA) was used to analyze the data.

Over 85.7% (945/1,103) deworming coverage was achieved with the smart collars, and 91.4% (1,008/1,103) of dogs in smart deworming group were dewormed 6 times during the 6 months. The smart deworming collar increased the deworming coverage and frequency (Tables 1 and 2). The positive rate of *Echinococcus* antigen in canine feces decreased from 5.7% (17/300) to 0 after six months of smart-collar deworming (Table 3).

DISCUSSION

As stated above, the existing manual deworming

TABLE 1. Deworming coverage between the two groups in Kangma County, Shigatse City, Tibet from June to November 2020.

Group	Number of dogs (n)	Beginning deworming		Three months later		Six months later	
		Actual number covered (n)	Rate (%)	Actual number covered (n)	Rate (%)	Actual number covered (n)	Rate (%)
Smart collar deworming group	1,103	1,103	100.0	1,032	93.6	945	85.7
Manual deworming group	300	129	43.0	158	52.7	173	57.7

TABLE 2. Deworming frequencies between the two groups in Kangma County, Shigatse City, Tibet from June to November 2020.

Deworming frequency	Smart collar deworming group		Manual deworming group	
	Number of dogs (n)	Constituent ratio (%)	Number of dogs (n)	Constituent ratio (%)
0	0	0.0	19	6.3
1	9	0.8	43	14.3
2	16	1.5	29	9.7
3	23	2.1	25	8.3
4	21	1.9	30	10.0
5	26	2.5	33	11.0
6	1,008*	91.4	121	40.3
Total	1,103	100.0	300	100.0

* The number 1,008 sums 945 and 63, where 945 is the number of the dogs with smart deworming collars still attached after six months, and 63 is the number of the dogs which although the smart deworming collars were removed by their owners, the smart deworming collars still ran well to deliver the bait containing praziquantel once a month, and the owners fed the baits to the dogs.

TABLE 3. Positive rates of *Echinococcus* antigen in canine feces between the two groups in Kangma County, Shigatse City, Tibet, from June to November 2020.

Deworming time	Smart deworming group			Manual deworming group			X^2	*p*
	Test numbers (n)	Positive numbers (n)	Positive rate (%)	Test numbers (n)	Positive numbers (n)	Positive rate (%)		
Before deworming	300	17	5.7	300	15	5.0	0.132	>0.05
Three months later	300	1	0.3	300	13	4.3	10.531	<0.05
Six months later	300	0	0.0	300	14	4.7	14.334	<0.05

methods (each dog, once a month) involved significant challenges, especially in China's less developed and more dispersed nomadic communities. In this study, the smart deworming collar was employed to deliver bait containing PZQ for dogs with many advantages: 1) deworming automatically as the smart collar only needs to be attached to the dog once a year and will deliver bait containing PZQ 12 times automatically, which greatly saves originally planned manpower and cost; 2) deworming regularly; 3) deworming quantitatively and with conditions for each individual dog; 4) digital smart telemanagement and control as after the dog is attached a smart collar, the RMS will automatically identify and analyze the related information and remotely monitor the status of the collar in real time without having to enter the scene; and 5) predominant characteristics of being waterproof, anti-collision, and cold-proof to ensure it runs well in the harsh climate. The results of this study illustrated that over 85.7% (945/1,103) of deworming coverage was achieved by the smart collar, and a 91.4% (1,008/1,103) monthly deworming rate was achieved in which the dogs in smart deworming group were dewormed 6 times within 6 months. These conditions basically met the standard of '4–8 times per year' and 'at least >90% of registered dogs' recommended by the WHO/OIE (*6*). Although the deworming coverage and frequency of the smart collar group were decreased, it was still much higher than those of manual deworming group.

The acceptable prevalence of canine echinococcosis recommended by WHO is <0.01% after an 'attack' phase of 5–10 years of regular dosing for registered dogs (*7*). In this study, after 6-months of smart deworming, the positive rates of *Echinococcus* antigen in canine feces decreased significantly from 5.7% (17/300) to 0, but in manual deworming group, the change of the positive rates of *Echinococcus* antigen in canine feces was not yet significant. The results implied that deworming by smart collar was a more efficient alternative to reduce the positive rate of *Echinococcus* antigen in canine feces.

The six-months evaluation has shown that there are obvious advantages and significant public health significance in improving the deworming coverage and frequency, reducing the positive rate of *Echinococcus* antigen in canine feces, and providing stronger protection than manual deworming. This study was limited by its relatively short evaluation period, and the actual effect of implementation still needs to be evaluated for a longer time.

Based on the findings of this study, the government should increase funds to support the application of the smart deworming collar, professional institutions should make further improvements based on the problems discovered in the actual application, and health promotion and education for dog owners should also be strengthened to improve their willingness and skills in attaching smart collars. In addition, the potential impact on dogs and associated economics all need further investigation.

Acknowledgements: Shigatse City Center for Disease Control and Prevention, Kangma County Center for Disease Control and Prevention, Kangma County Agriculture and Animal Husbandry Bureau.

Conflicts of interest: The authors declare no competing interests.

Funding: This work was supported by the Ganzi Prefecture Workgroup Projects for Echinococcosis Prevention and Control, China CDC (2016-07, 2017-06, 2018-02, 2019-02), the NHC Key Laboratory of Echinococcosis Prevention and Control Project (Supported by the Non-profit Central Research Institute Fund of Chinese Academy of Medical Sciences, 2019PT320004), and the Key R & D Transformation Projects, Qinghai (2020-SF-133).

doi: 10.46234/ccdcw2020.265

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Submitted: December 06, 2020; Accepted: December 17, 2020

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