Investigating the Application of Nanomedicines in Improving the Hydatid Cysts Treatment

Hassan Borji[1*], Soheil Sadr[1], Shakiba Nazemian[1], Cinzia Santucciu[2], Abbas Rahdar[3] and Sadanand Pandey[4]

[1]*Department of Pathobiology, Faculty of Veterinary Medicine, Ferdowsi University of Mashhad, Mashhad, Iran.*

[2]*WOAH and NRL for Echinococcosis, Animal Health, Istituto Zooprofilattico Sperimentale della Sardegna, Sassari, Italy*

[3]*Department of Physics, University of Zabol, Zabol, Iran.*

[4]*Department of Chemistry, College of Natural Science, Yeungnam University, 280 Daehak-Ro, Gyeongsan 38541, Korea*

**Corresponding author: hborji@um.ac.ir*

Abstract- Hydatid cyst is a serious zoonotic disease caused by the larval stage of the parasite *Echinococcus granulosus sensu lato* and is particularly prevalent in rural areas and communities where sheep and dogs are raised together. Current treatments include surgery, used only as save-live option, and less invasive techniques, such as watch and wait or cystic liquid aspiration. All cures are used along with drug therapy, and often this is the only option, but significant limitations such as side effects, insufficient drug penetration into the cyst, and drug resistance are often observed. Hence, the current review aims to investigate the application of nanoparticles and nanocoatings in treating hydatid cysts. Moreover, the role of nanotechnology tools in enhancing the effectiveness of conventional and herbal medicines is discussed, and the advantages, challenges, and future of these methods are analyzed. In this regard, nanotechnology has been introduced as a new approach to improve the effectiveness of treatments. Nanodrugs have been widely used to treat hydatid cysts due to their properties, such as increased solubility, stability, and bioavailability of drugs, the ability to target the cyst site, and reduced side effects. Nanocapsules have been investigated for enhancing drugs such as albendazole as a standard treatment to increase the penetration of the drug into the cyst wall. Additionally, nanoformulations based on plant compounds such as curcumin and flavonoids have shown significant antiparasitic and anti-inflammatory effects. In conclusion, nanotechnology has opened up new hopes for increasing efficacy and reducing the side effects of existing methods for hydatid cyst treatment.

Keywords: Nanotechnology, Hydatid Cyst, Nanoparticles, Nanocoatings

INTRODUCTION

Cystic echinococcosis (CE) is a parasitic disease caused by the infection of the larval stage of the parasite *Echinococcus* granulosus *sensu lato (s.l.)*. CE is a significant public health concern, especially in rural areas and communities where the biological cycle is perpetuated by sheep (intermediate host) and dogs (definitive host) raised together [1]. Humans are accidental intermediate hosts of the parasite through the consumption of contaminated food or contact with infected dogs. Once the parasite enters the body, the larvae settle mainly in the liver and lungs, forming fluid-filled cysts that can cause complications such as mechanical obstruction, secondary infections, and even death [2].

Nanotechnology has emerged as a novel approach to treating hydatid cysts by providing targeted drug delivery, increased efficacy, and reduced side effects [3]. Nanotools have improved the ability of drugs to penetrate the cyst wall and achieve long-term therapeutic effects by providing advanced drug delivery systems. Hence, the current review aims to investigate the application of nanoparticles and nanocoatings in treating hydatid cysts.

NANOTECHNOLOGY

In recent decades, nanotechnology has emerged as a powerful tool for treating several diseases, comprehensive of chronic and infectious diseases [4]. In particular, Nanotechnology has significantly benefited CE therapy by providing advanced drug delivery systems. One of the main challenges in the treatment of hydatid cysts is the lacking in penetration of drugs into the cyst wall and the low bioavailability of antiparasitic drugs. Due to their small size and high active surface area, nanoparticles can penetrate deeper tissues and cyst walls [5].

Another advantage of nanotechnology is the possibility of designing targeted drug delivery systems. These systems deliver drugs directly to the cyst site and prevent non-specific

distribution of the drug in the body [6]. This feature increases the effectiveness of the treatment and reduces the risk of systemic side effects [7].

Nanoformulations can also increase the solubility and stability of antiparasitic drugs. Using nanocapsules with herbal compounds such as curcumin enhances anti-inflammatory and antiparasitic effects. As a transformative approach, nanotechnology can help overcome the challenges in treating hydatid cysts [8].

CHEMICAL AND HERBAL MEDICINES

Albendazole is known as one of the primary drugs in treating CE, but its low bioavailability and the need for high doses are its main limitations [9]. Lipid and polymer nanoparticles have been developed to enhance the efficacy of this drug. Albendazole-based nanoformulations and nanocapsules have increased the drug's absorption into the cyst wall and enhanced its antiparasitic effects [10]. These nanoparticles can also increase the drug's half-life and reduce the need for repeated administration.

Regarding herbal compounds, curcumin, as a natural anti-inflammatory and antiparasitic compound, has attracted much attention. However, limitations such as its low solubility and rapid metabolism in the body have led to the development of curcumin-based nanoformulations and nanocapsules. These nanoparticles have enhanced curcumin's therapeutic effects and enabled its targeted delivery to the cyst site [5].

Moreover, nanocoatings for other plant compounds, such as flavonoids and essential oils, can help improve their efficacy and reduce their side effects. Nanotechnology can be combined with existing therapeutic methods and is an effective supplement in treating hydatid cysts [11].

CONCLUSION

As a novel approach to treating CE, nanotechnology has opened up new hopes for increasing efficacy and reducing the side effects of existing methods. Nanoparticles and nanocoatings have provided effective solutions to overcome existing limitations by improving the properties of conventional drugs.

ACKNOWLEDGMENT

Conceptualization: Abbas Rahdar, Hassan Borji; Methodology: All Authors; Writing - original draft preparation: All Authors; Writing - review and editing: Soheil Sadr; Supervision: Hassan Borji. We thank the Ferdowsi University of Mashhad Research Deputy for their support.

REFERENCES

1. Shnawa BH, Al-Ali SJ, Swar SO. Nanoparticles as a new approach for treating hydatid cyst disease. Veterinary Pathobiology and Public Health. 2021;1:180-9.
2. Cheraghipour K, Rouzbahani AK, Fallahi S, Taherpour F, Moradifard F, Shakib P, et al. Recent advances in therapeutic strategies against hydatid cysts using nanomaterials: A systematic review. Letters in Drug Design & Discovery. 2023;20:000-.
3. Sadr S, Lotfalizadeh N, Abbasi AM, Soleymani N, Hajjafari A, Roohbaksh Amooli Moghadam E, et al. Challenges and prospective of enhancing hydatid cyst chemotherapy by nanotechnology and the future of nanobiosensors for diagnosis. Tropical medicine and infectious disease. 2023;8(11):494.
4. Dhahi TS, Dafhalla AKY, Saad SA, Zayan DMI, Ahmed AET, Elobaid ME, et al. The importance, benefits, and future of nanobiosensors for infectious diseases. Biotechnology and Applied Biochemistry. 2024;71(2):429-45.
5. Sorouri N, Soleymani N, Sadr S, Rahdar

A, Ebrahimzadeh E, Borji H. Investigating the Therapeutic Effects of Curcumin Nanocapsules in Hydatid Cyst-Infected mice. Experimental Parasitology. 2024:108860.
6. Mahmoudvand H, Harandi MF, Shakibaie M, Aflatoonian MR, ZiaAli N, Makki MS, et al. Scolicidal effects of biogenic selenium nanoparticles against protoscolices of hydatid cysts. International journal of surgery. 2014;12(5):399-403.
7. Soleymani N, Sadr S, Santucciu C, Rahdar A, Masala G, Borji H. Evaluation of the In-Vitro Effects of Albendazole, Mebendazole, and Praziquantel Nanocapsules against Protoscolices of Hydatid Cyst. Pathogens. 2024;13(9):790.
8. Shnawa BH. Advances in the use of nanoparticles as anti-cystic echinococcosis agents: A review article. Journal of Pharmaceutical Research International. 2018;24(1):1-14.
9. Bakhtiar NM, Akbarzadeh A, Casulli A, Mahami-Oskouei M, Ahmadpour E, Nami S, et al. Therapeutic efficacy of nanocompounds in the treatment of cystic and alveolar echinococcoses: challenges and future prospects. Parasitology Research. 2019;118:2455-66.
10. Norouzi R, Ataei A, Hejazy M, Noreddin A, El Zowalaty ME. Scolicidal effects of nanoparticles against hydatid cyst protoscolices in vitro. International journal of nanomedicine. 2020:1095-100.
11. Raziani Y, Shakib P, Rashidipour M, Cheraghipour K, Ghasemian Yadegari J, Mahmoudvand H. Green synthesis, characterization, and Antiparasitic Effects of Gold nanoparticles against *Echinococcus granulosus* Protoscoleces. Tropical medicine and infectious disease. 2023;8(6):313.