Iraqi Journal of Veterinary Sciences

www.vetmedmosul.com

The influence of nuclear radiation in expression of CD4 using immunohistochemical features in some organs of rats infested with *Echinococcus granulosus* and assessment of liver enzymes

S.Y. Yousif[1], O.A. Najm[1] and Y.Y. Kassim[2]

[1]Department of Biology, [2]Department of Physics, College of Education for Pure Science, University of Mosul, Mosul Iraq

Article information

Article history:
Received 16 June 2025
Accepted 13 August 2025
Published 17 September 2025

Keywords:
Liver enzymes
Hydatid cyst
Nuclear radiation
Protoscoleces viability

Correspondence:
S.Y. Yousif
suhyy1974@uomosul.edu.iq

Abstract

Cystic echinococcosis (CE) also known as hydatidosis is a widespread health problem worldwide caused by *Echinococcus* tapeworms. The research aims to explore how nuclear particle affects the levels of CD4 protein expression in body organs (liver, spleen and intestine) and the enzymes related to liver functions (Glutamate Pyruvate Transaminase (GPT), Glutamate Oxaloacetate Transaminase (GOT) and Alkaline Phosphatase (ALP)) in rats infected with hydatid cyst disease. Samples of hydatid cyst and protoscoleces were obtained from sheep livers and their viability was evaluated. The protoscoleces were exposed to nuclear particles at different energy (2.3 and 4.3MeV) and durations to study their viability. Protoscoleces, irradiated and non-irradiated, were injected into six groups of rats. The physiological and biochemical impacts were monitored over time spans. The present study indicated that longer exposures of protoscoleces to nuclear particles led to increase killing rates. Liver and spleen weights as their hypertrophy index return to normal after five months. Liver enzyme levels (GPT, GOT and ALP) remain within the range after 4 to 5 months of infection. Extended nuclear particles contributed to the elimination of parasite and tissue healing. The present study highlights how nuclear particle could be used as a treatment for hydatid cyst infection by impacting their survival rates.

DOI: 10.33899/ijvs.2025.161566.4362,

Introduction

Hydatid disease or echinococcosis is an illness transmitted by *Echinococcus* spp. that brings about health and financial challenges worldwide especially in areas relying heavily on animal husbandry for their livelihoods (1). Canids are the definitive host of the adult stage of *Echinococcus* spp. The infection occurs when hosts ingest eggs of the parasite and develop into the larval stage, hydatid cyst, which found in the most organs of domestic animals such as cattle, sheep and camels this cyst grows slowly from inside to outside, it consists germinal layer and laminated layer and filled with hydatid cyst fluid which results from the secretion of soluble components by the germinal layer and may also provide nutrients necessary for the growth and development of hydatid cysts and of the protoscoleces that are collected within the hydatid cyst fluid, these protoscoleces will generate the adult worm in definitive hosts. The infection mainly targets the liver and lungs by forming hydatid cysts that can disrupt organ function and result in complications (2). Zai *et al.* (3) demonstrated that liver is the main target organ for hydatidosis. The larval stage of Echinococcosis lead to formation of fibrotic cysts which lead to develop a histological barrier between healthy liver tissues and damaged that decrease host's inflammatory defenses against protoscoleces and support the protoscoleces to invasion in the liver (4-7). Hepatic damage is accompanied with changes in the level liver function enzymes like majority of especially GPT, GOT and ALP. The level of liver enzyme is depended

on the value of harm or necrosis in hepatic tissue. A raise in liver enzymes are showing various kinds of liver damage (8). The body's defense against *Echinococcus* infection includes pathways that activate and regulate T cell subsets like CD4+ for managing the immune response against the parasite (9). There has been a rising interest in the potential uses of nuclear particle in parasitology especially alpha particles due to its ability to deactivate harmful agents (10). Alpha particles possess an energy transfer capability that allows them to inflict significant harm on biological tissues and pathogens over short distances (11-13). Nevertheless, the effects of this type of radiation on host immune reactions such as CD4 protein levels and the specific impacts on different organs have not been thoroughly investigated yet (14).

Moreover, the impact of radiation on liver function affected by echinococcosis requires exploration to evaluate possible treatment benefits or side effects. The current study focused on examining how nuclear particle radiation impacts the survival of *Echinococcus* protoscoleces and the related physiological and immune reactions in rats as a model organism. This study aims to understand the relationship between radiation exposure and its effects on liver function enzymes and CD4 expression in organs in the context of hydatid disease. The results could enhance our knowledge of using radiation-based treatments for infections and their implications for overall host well-being.

Materials and methods

Ethical approval

Ethical approvals references number UM.VET.2024.126, dated January 2, 2024 for handling animals was awarded by institutional Animal Care and Use Committee in College of Veterinary Medicine, University of Mosul, Mosul, Iraq.

Sample collection and viability assessment

Hydatid cysts were obtained from the sheep livers at the slaughterhouse in Mosul City. Then checked promptly to see if they contained protoscoleces by using an aqueous eosin dye (0.1%) to distinguish between live (green colored ones area) and dead (red colored ones) under a microscope. The movement of the protoscoleces was regarded as an indicator of viability with samples showing 98%- 99% viability being selected for analysis according to Smith and Barret method (15).

Isolation of protoscoleces

According to Smyth (16) cysts were sterilized externally using 1% alcoholic iodine solution and punctured using a sterile 21G needle to aspirate cyst fluid into a 20 mL syringe. The fluid was centrifuged at 3000 rpm for three cycles each time adding penicillin (2000 IU) and streptomycin (1 g/L) to the wash solution (PBS, pH 7.2). Viability of protoscoleces were suspended in sterile PBS and stored for further experiments.

Viability calculation

A 20 µL protoscolex suspension was mixed with an equal volume of 0.1% eosin dye and examined microscopically. The viability percentage was calculated as follows viability (%) = (number of liver protoscoleces / total protoscoleces)*100. The assessment was performed three times and the mean viability was recorded (16).

Radiation exposure of protoscoleces

Protoscoleces were exhibited to nuclear particles Americium-241 (^{241}Am) at two energies (2.3 and 4.3MeV) for varying durations (17). For each duration 100 µL of protoscoleces were irradiated. At 4.3MeV: Exposure durations were 5, 20, 45, 60, and 90 minutes. At 2.3MeV: Exposure durations were 10, 30, 50, 60, and 90 minutes. Post-exposure, the percentage of viable and dead protoscoleces was calculated microscopically in the nuclear laboratory in the college of Education for Pure Science by using Americium-241 (^{241}Am) source in the activity (1µCi).

Experimental design

Thirty-five adult rats were divided into seven groups (n=5) per group. Group 1 rats were used as negative control. Group 2 rats injected, intraperitoneally, with protoscoleces irradiated for 60 minutes then sacrificed after 4 months. Group 3 rats injected, intraperitoneally, with protoscoleces irradiated for 60 minutes then they sacrificed after 5 months. Group 4 rats injected, intraperitoneally, with protoscoleces irradiated for 90 minutes then sacrificed after 4 months. Group 5 rats injected, intraperitoneally, with protoscoleces irradiated for 90 minutes then sacrificed after 5 months. Group 6 (Positive control) rats injected, intraperitoneally, with non-irradiated protoscoleces and they sacrificed after 4 months. Group 7 (Positive control) rats injected, intraperitoneally, with non-irradiated protoscoleces then sacrificed after 5 months.

Immunohistochemical

Immunohistochemical analysis of CD4 expression were used according to Alturkistani *et al*. (18). Preparation of tissues, liver and spleen samples were collected after euthanizing rats then fixed in 10% neutral buffered formalin and embedded in paraffin. 5µm for both samples were prepared utilizing a microtome.

Immunohistochemical staining

Slides were removed in xylene and rehydrated estimated using different levels of alcohols. Antigen recovery was completed by a citrate buffer (pH 6.0) at 95°C for twenty minutes. The activity of endogenous peroxidase was plugged via incubating divisions for 3% H2O2. CD4 expression was appreciated semi-quantitatively established upon staining

density and the proportion of positively stained cells. compared Results with experimental sets. Slides had been incubated overnight at 4°C with a monoclonal anti-CD4 antibody. After washing, sections had been incubated with a biotinylated antibody, streptavidin-HRP. The chromogenic material application di-aminobenzidine (DAB). Slides were dyed by hematoxylin, desiccated, and fixed.

Weight and hypertrophy index of liver and spleen

Liver and spleen hypertrophy index were estimated according to Kroeze and Tanner (19) as follows: organ index = (organ weight/(body weight-organ weight)*100.

Liver function tests

Serum was analyzed for liver enzymes (GOT, GPT, and ALK) depending on El-Lehieh *et al.* (20).

Statistical analysis

One-way Analysis of Variance (ANOVA) was used to test the differences between groups followed by Tukey's post-hoc test for multiple comparisons to determine statistically significant differences among the groups. The level of statistical significance was set at ($p < 0.05$) with values below this threshold considered indicative of significant differences between the groups. The results were presented as mean±standard deviation to illustrate the variation within each group (21).

Results

The data in Table 1 illustrate the effects of nuclear particles irradiation on living protoscoleces at energy 4.3MeV with varying exposure durations (Table 1). The data presented in Table 2 illustrates the killing rates of living protoscoleces exposed to nuclear particles at 2.3MeV energy over varying durations. The results indicate a significant relationship between exposure time and killing efficiency.

The table 3 shows liver and spleen weights and hypertrophy index after five months of exposure to different conditions. Liver weight, the positive control group showed a higher liver weight (3.78±0.1) compared to the 60minutes radiation group (2.86±0.06) and the 90minutes radiation group (2.92±0.07). The p-value is < 0.001 indicating a highly significant difference between the positive control group and the other groups. Hypertrophy Index (Liver), the positive control group had the highest liver hypertrophy index (68.4±1.03) compared to the other groups (47±1.51 and 49.8±1.06). The p-value is < 0.001 suggesting a highly significant difference. Spleen weight, the positive control group showed a higher spleen weight (2.44±0.13) compared to the other groups (1.84±0.08 and 1.94±0.11). The p-value is 0.002 indicating a significant difference between the groups. Hypertrophy Index (Spleen), the positive control group had the highest spleen hypertrophy index (39±4.4) compared to the other groups (27.8±1.88 and 29.8±1.24). The p-value is 0.037 showing a significant difference between the groups.

Table 1: Killing rate of living protoscoleces by nuclear particles at energy 4.3MeV at different exposure durations

Exposure	Killing rate (%)
10 minutes	20
30 minutes	40
50 minutes	49
60 minutes	80
90 minutes	87

Table 2: Killing rate of living protocoleces by nuclear particles at 2.3MeV energy at different exposure durations

Exposure	Killing rate (%)
10 minutes	10
30 minutes	30
50 minutes	69
60 minutes	85
90 minutes	95

The table 4 shows the effects of nuclear particle exposure on liver enzymes (GPT, GOT, and ALP) after four months of exposure. The data is presented as Mean±Standard Error and the reference ranges for the enzymes are provided. Glutamate Pyruvate Transaminase (GPT), the positive control group showed significantly higher GPT levels (56.2±13.3U/L) compared to the radiation exposure groups (23.2±2.59U/L for 60 minutes and 20.2±5.93U/L for 90 minutes). The p-value is 0.031 indicating a statistically significant difference between the positive control group and the radiation exposure groups. The positive control group's GPT range (4-44) indicating elevated enzyme levels. Glutamate Oxaloacetate Transaminase (GOT), the positive control group showed higher GOT levels (156.8±37.55U/L) compared to both radiation exposure groups (70.4±5.95U/L for 60 minutes and 62.21±5.46U/L for 90 minutes). The p-value is 0.034 indicating a significant difference. The positive control group's GOT levels are elevated compared to the GOT range (8-38) indicating liver stress. Alkaline Phosphatase (ALP), the positive control group showed significantly higher ALP levels (381.8±18.16U/L) compared to both radiation exposure groups (126±11.33U/L for 60 minutes and 23.4±18.82U/L for 90 minutes). The p-value is <0.001 indicating a highly significant difference between the groups. The positive control group’s ALP levels are well above the ALP range (114-338) suggesting liver dysfunction.

Table 3: Liver and spleen weights and their hypertrophy index after five months of exposure

Exposure	Liver weight (gm)	Hypertrophy index (liver)	Spleen weight (gm)	Hypertrophy index (spleen)
Control	3.78±0.1*	68.4±1.03*	2.44±0.13*	39±4.4*
60 minutes	2.86±0.06	47±1.51	1.84±0.08	27.8±1.88
90 minutes	2.92±0.07	49.8±1.06	1.94±0.11	29.8±1.24
p-value	<0.001	<0.001	0.002	0.037

Data expressed as Mean±standard error, (no. rats = 5). *There is a significant difference from other groups at $p \leq 0.05$.

Table 4: Effect of nuclear particles on liver enzymes after four months of exposure

Exposure	GPT U/L	GOT U/L	ALP U/L
Control	56.2±13.3*	156.8±37.5*	381.8±18.1*
60 minutes	23.2±2.5	70.4±5.9	126±11.3
90 minutes	20.2±5.9	62.21±5.4	123.4±18.8
p-value	0.031	0.034	<0.001
Reference	4-44	8-38	114-338

Histopathological examination

Figure 1 shows rat's liver of hydatid cyst infected (positive control) group without radiation, [A]: after 4 months and [B]: after 5 months shows presents of laminated membrane of protoscoleces (double head arrow), surrounding by increased fibrous tissue (black arrow), infiltration of inflammatory cells in portal area (green arrow) and necrosis of hepatocytes (blue arrow) with increased fibrous tissue between it (yellow arrow) [A and B]. After 4 months of infected rats with protoscoleces exposure to nuclear particles for 60minutes mild necrosis and vacuolar degeneration of the hepatocytes, stenosis of sinusoids and mild infiltration of inflammatory cells were recorded [A]. On the other hand, mild necrosis of the hepatocytes, dilatation of sinusoids was observed after 4 months of infected rats with protoscoleces exposure to nuclear particles for 90minutes [B] (Figure 2).

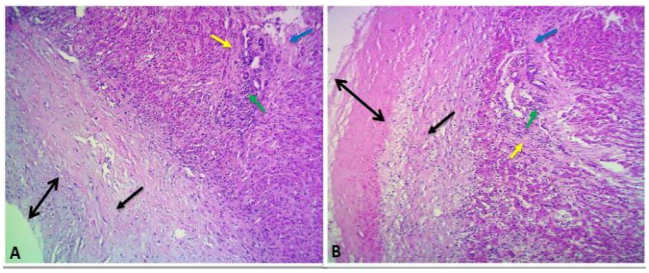

Figure 1: photomicrograph of rat's liver of hydatid cyst infected (positive control) group, [A]: after 4 months and [B]: after 5 months shows presents of laminated membrane of hydatid cyst (double head arrow), surrounding by increased fibrous tissue (black arrow), infiltration of inflammatory cells in portal area (green arrow) and necrosis of hepatocytes (blue arrow) with increased fibrous tissue between it (yellow arrow). 100X.

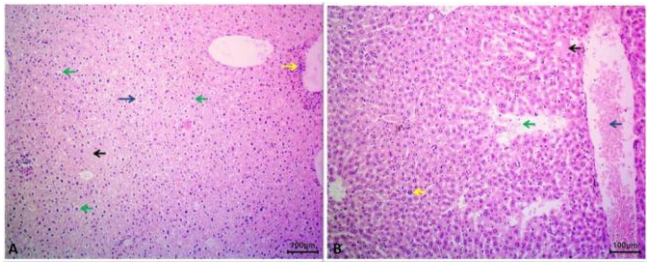

Figure 2: photomicrograph of rat's liver. [A]: After 4 months of infected rats with protoscoleces exposure to nuclear particles for 60minutes: mild necrosis (black arrow) and vacuolar degeneration of the hepatocytes (green arrow), stenosis of sinusoids (blue arrow) and mild infiltration of inflammatory cells (yellow arrow). [B]: after 4 months of infected rats with protoscoleces exposure to nuclear particles for 90minutes: mild necrosis of the hepatocytes (black arrow), dilatation of sinusoids (green arrow).

Figure 3 shows very mild vacuolar degeneration of hepatocytes and congestion of central vein [A] after 5 months of infected rats with protoscoleces exposure to nuclear particles for 60minute. On the other hand, normal architecture of hepatic tissue, central vein and portal area were seen after 5 months of infected rats with protoscoleces exposure to nuclear particles for 90 minutes [B].

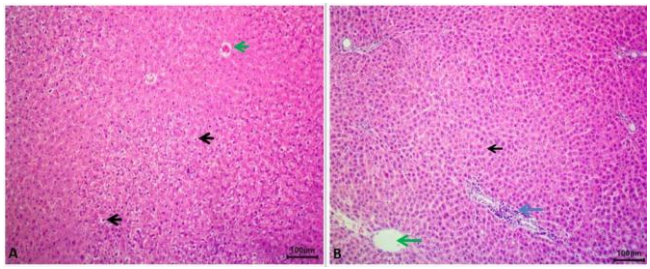

Figure 3: photomicrograph of rat's liver. [A]: after 5 months of infected rats with protoscoleces exposure to nuclear particles for 60minute: very mild vacuolar degeneration of hepatocytes (black arrow), and congestion of central vein (green arrow). [B]: after 5 months of infected rats with protoscoleces exposure to nuclear particles for 90minutes: intact architecture of hepatocytes (black arrow), central vein (green arrow) and portal area (blue arrow). 100X.

Immunohistochemical examination

Immunohistochemical expression of CD4 of the negative control groups were shown in figure 4. [A]: Liver; [B]: spleen, [C]: intestine. Immunohistochemical analysis of CD4 expression in the liver, spleen, and intestine of rats infected with hydatid cysts showed varying intensities across different treatment durations and tissues. In the liver (Figure 5), CD4 expression in the 4-month infected group demonstrated very intense expression in the 60minutes radiation treatment group [A] and intense expression in the 90minutes radiation treatment group [B]. In the 5-month infected group, moderate expression was observed in the 60minutes treatment group [C], while weak expression was detected in the 90minutes treatment group [D]. Similarly, in the spleen (Figure 6), the 4-month infected group displayed very intense expression of CD4 in the 60minutes radiation treatment group [A] and intense expression in the 90minutes group [B]. In the 5-month infected group, CD4 expression was moderate in the 60minutes treatment group [C] and weak in the 90minutes group [D]. In the intestine (Figure 7) the 4-month infected group exhibited very intense expression of CD4 in the 60minutes radiation treatment group [A] and intense expression in the 90minutes group [B]. In the 5-month infected group, moderate expression was observed in the 60minutes treatment group [C] and weak expression was noted in the 90minutes group [D]. All samples were examined at 100X magnification, and had a scale bar of 100 µm.

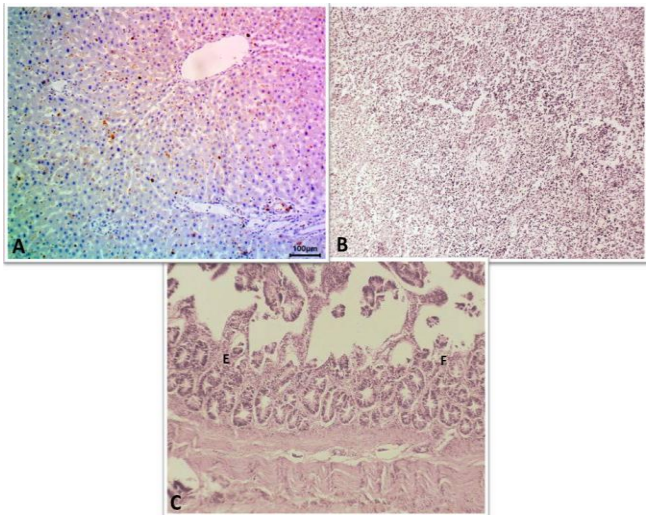

Figure 4: Immunohistochemical expression of CD4 of the negative control. [A]: Liver; [B]: spleen, [C]: intestine. They reveal weak expression. 100X. scale-bar=100µm.

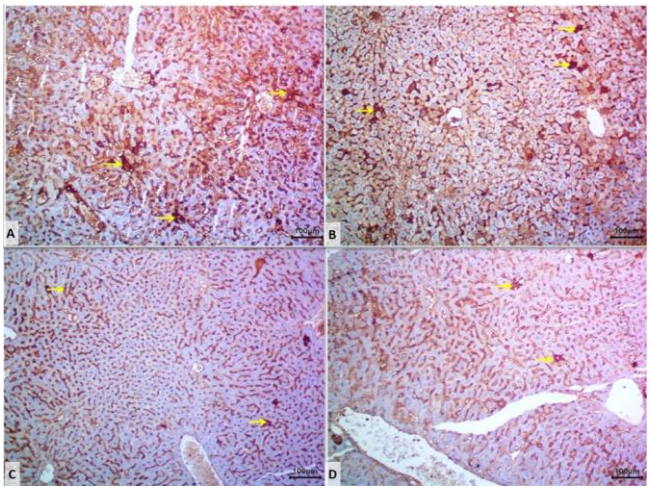

Figure 5: Immunohistochemical expression of CD4 in the Rat's liver. [A& B]: 4 months and [C& D]: 5 months hydatid cyst infected. [A]: 60minutes radiation treatment group: very intense expression (arrows). [B]: 90minutes radiation treatment group: intense expression (arrows). [C]: 60minutes radiation treatment group: moderate expression (arrows). [D]: 90minutes radiation treatment group: weak expression (arrows); 100X. scale-bar=100µm.

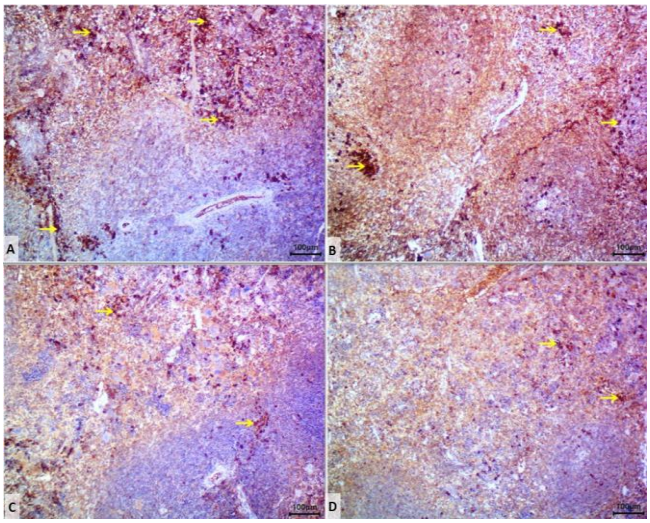

Figure 6: Immunohistochemical expression of CD4 in the Rat's spleen. [A& B]: 4 months and [C& D]: 5 months hydatid cyst infected. [A]: 60minutes radiation treatment group: very intense expression (arrows). [B]: 90minutes radiation treatment group: intense expression (arrows). [C]: 60minutes radiation treatment group: moderate expression (arrows). [D]: 90minutes radiation treatment group: weak expression (arrows) 100X. scale-bar=100µm.

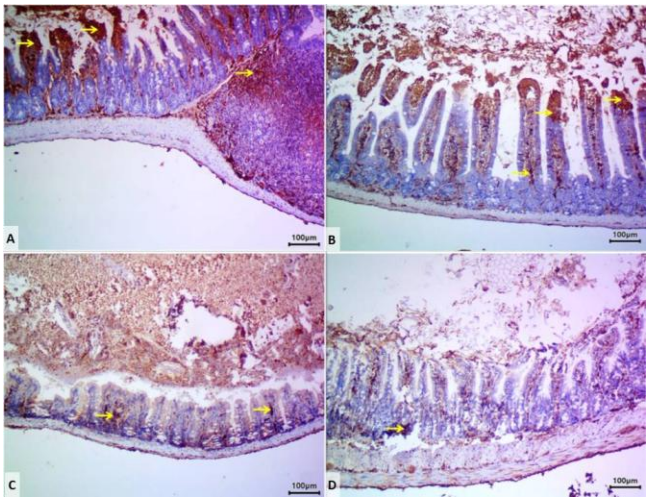

Figure 7: Immunohistochemical expression of CD4 in the Rat's intestine. [A& B]: 4 months and [C& D]: 5 months hydatid cyst infected. [A]: 60minutes radiation treatment group: very intense expression (arrows). [B]: 90minutes radiation treatment group: intense expression (arrows). [C]: 60minutes radiation treatment group: moderate expression (arrows). [D]: 90minutes radiation treatment group: weak expression (arrows) 100X. scale-bar=100µm.

Discussion

Hydatid disease known as echinococcosis also known as cystic echinococcosis is a neglected zoonotic illness brought on by *Echinicoccus* spp. (21,22). The present study investigated the therapeutic effects of nuclear particle on hydatid cyst and its impact on immune responses, organ hypertrophy index, liver enzyme levels, and histological changes of tissues in infected rats. The findings emphasize the dual role of radiation in reducing parasite viability and modulating host immune and physiological responses, these results agree with the findings of other studies (23,24). Radiation effectively reduced protoscolex viability in an energy and duration-dependent manner. A 90-minute exposure at 4.3 MeV achieved an 87% killing rate, while at 2.3 MeV the rate increased to 95%. These results consistent with that of Raziani *et al.* (25) who highlight the efficacy of alpha particles in damaging parasite DNA and cellular structures. Other researchers demonstrated that molecular level and alpha particles directly damage the DNA of parasitic cells by inducing double-strand breaks in the DNA, these breaks are highly detrimental to the cells especially if not properly repaired. Additionally, alpha particles generate reactive molecules such as reactive oxygen species (ROS) which cause further damage to cellular membranes, proteins, and DNA (26-28). The increased effect with reduced distance is due to the higher linear energy transfer (LET) to the cells which raises the likelihood of causing lethal damage (29). Moreover, increased exposure duration results in cells receiving higher radiation doses enhancing cumulative damage and reducing survival chances (30). The observed efficiency at 2.3 MeV suggests prolonged exposure compensates for reduced radiation intensity at greater distances, aligning with previous findings on radiation's cytotoxicity in parasitic models (31). In the current study rats in the positive control group exhibited significant liver and spleen hypertrophy index, indicative of the metabolic and immune burden imposed by hydatid cyst infection. Radiation treatment reduced organ weights and hypertrophy index with significant differences noted ($p < 0.001$ for liver; $p = 0.037$ for spleen). These results are in agreement with Szewczyk-Golec's *et al.* (32) and Eissa *et al.* (33) findings which suggested that the reduction in organ weight and hypertrophy index decreased parasite viability and associated pathological effects reflecting the therapeutic potential of radiation in alleviating organ stress.

In the present study, infected rats with protoscoleces without radiation treatment displayed elevated GPT, GOT, and ALP levels indicating liver damage and biliary dysfunction. Radiation-treated groups showed significantly reduced enzyme levels ($p = 0.031$ for GPT, $p = 0.034$ for GOT, $p < 0.001$ for ALP), correlating with decreased parasite burden and improved liver function. The group exposed to radiation for 60 minutes showed decreased enzyme levels in comparison to the group exposed for 90 minutes indicating that extended exposure could worsen tissue stress even as it decreases infection levels. Ilderbayev *et al.* (34); Benchabane *et al*. (35) suggest that variation in enzyme levels may be clarified by the rise in radicals and oxidative stress due to prolonged exposure to radiation leading to tissue damage Heightened local inflammation. Conversely the decrease in infections could be attributed to the improved efficiency of radiation in eliminating parasite with exposure periods. However, this effectiveness may compromise the integrity of tissues (36). The results underscore the significance of striking an equilibrium between the length of radiation exposure and its healing advantages versus its effects since extended exposure could lead to negative tissue outcomes that overshadow the gains in infection reduction .

The examination of tissue samples showed liver damage in the test group that received treatment, then radiation therapy due to conditions like cell death in the hepatocytes and abnormal changes in cell structure and function along with decreased blood flow and blockage, in central veins caused by inflammation. In the group treated for 60 minutes on infected subjects after 120 days of infection observations indicated some tissue damage and narrowing of blood vessels; however, in the group treated for 90 minutes there was an increase, in the activity of Kupffer cells suggesting a response leading to clearance of parasites. Groups infected for 60 minutes displayed degeneration and congestion, in the central vein after 6 months of infection. Notably, the 90 minutes group exhibited intact liver architecture, reflecting

effective parasite control and tissue recovery. These improvements highlight radiation's ability to restore liver integrity over time, with longer exposure durations demonstrating greater efficacy in mitigating histopathological damage (37,38).

In the present study, CD4 expression in the liver, spleen, and intestine varied with infection duration and radiation exposure. After 4 months of injected rats with protoscoleces exposed to nuclear particles for 60 minutes, exhibited very intense CD4 expression across tissues, while those treated for 90 minutes showed intense expression. At 5 months, CD4 expression decreased to moderate (60 minutes treatment) and weak (90 minutes treatment) levels. In Liver, Intense CD4 expression at 4 months reflects an active immune response to infection. The decline at 5 months correlates with reduced parasite burden and diminished immune stimulation suggesting tissue recovery and immune regulation (39). In Spleen, Similar patterns in CD4 expression indicate systemic immune modulation. The reduced expression at 5 months highlights the therapeutic efficacy of prolonged radiation in suppressing parasitic antigens (40,41). In Intestine, CD4 trends mirrored other tissues, with reduced expression at 5 months indicating localized immune resolution and potential tissue recovery. These results show an interplay, between boosting the response and controlling it to prevent infection and reduce long term inflammation.

Conclusion

The present study investigated the therapeutic effects of nuclear particle on hydatid cyst and its impact on immune responses, organ hypertrophy index, liver enzyme levels, and histological changes of tissues in infected rats. Low energy of nuclear particles with increasing duration time reduces the viability of protoscoleces. Nuclear particles showed significantly reduced enzyme levels (GPT, GOT and ALP) correlating with decreased parasite burden and improved liver function. Nuclear particles induced immune response and enhanced CD4 expression which is varied in the liver, spleen and intestine according to infection duration and radiation exposure. These findings emphasize the dual role of radiation in reducing protoscoleces viability and modulating host immune and physiological responses, these discoveries lay the groundwork, for exploring how radiation therapy can be applied in treating illnesses.

Acknowledgment

The researchers extend their gratitude to the University of Mosul, College of Education for Pure Science for supporting the present study.

Conflicted interest

None

References

1. Hajjafari A, Sadr S, Santucciu C, Masala G, Bayat M, Lotfalizadeh N, Borji H, Partovi Moghaddam S, Hajjafari K. Advances in detecting cystic echinococcosis in intermediate hosts and new diagnostic tools: a literature review. Veterinary Sciences. 2024 May 21;11(6):227. DOI: 10.3390/vetsci11060227
2. Ahn CS, Han X, Bae YA, Ma X, Kim JT, Cai H, Yang HJ, Kang I, Wang H, Kong Y. Alteration of immunoproteome profile of *Echinococcus granulosus* hydatid fluid with progression of cystic echinococcosis. Parasit Vectors. 2015;8(1):10. DOI: 10.1186/s13071-014-0610-7
3. Zhai S, Yang Y, Zhou Y, Lai Q, Li K, Liu S, Li W, Gao F, Guan J. *Echinococcus granulosus*-induced liver damage through ferroptosis in rat model. Cells. 2025;14:328. DOI: 10.3390/cells14050328
4. Hama AA, Hassan ZI, Salih WM, Interisano M, Boufana B, Casulli A. A morphologically unusual *Echinococcus granulosus* (G1 genotype) cyst in a cow from Kurdistan-Iraq. Epidemiol. 2015;5:005. DOI: 10.4172/2161-1165.S2-005
5. Gao H, Pang H, Sun X, Zhang T, Jing T, Wang X, Mo X, Hu W. Effects of persistent *Echinococcus multilocularis* infections on hepatic fibrosis in mice. Chin J Schistosomiasis Control. 2021;33:54. [available at]
6. Díaz Á, Barrios AA, Grezzi L, Mouhape C, Jenkins SJ, Allen JE, Casaravilla C. Immunology of a unique biological structure: The *Echinococcus* laminated layer. Protein Cell. 2023;14:87-104. DOI: 10.1093/procel/pwac023
7. Jafari Y, Imani Baran A, Ahmadiafsha S. Th1/Th2/Th17 pattern in pregnant mice inoculated with live *Echinococcus granulosus* protoscolex. J Zoonotic Dis. 2020;4(4):36-50. DOI: 10.1016/j.jiph.2018.06.007
8. Abdulla SH. Comprehensive evaluation and management of liver hydatid cyst. Cihan Univ-Erbil Sci J. 2024;8(2):116-119. DOI: 10.24086/cuesj.v8n2y2024.pp116-119
9. Yarahmadov T, Wang J, Sanchez-Taltavull D, Rojas CAA, Brodie T, Büchi I, Keogh A, Gottstein B, Stroka D, Beldi G. Primary infection by *Echinococcus multilocularis* induces distinct patterns of cross talk between hepatic natural killer T cells and regulatory T cells in mice. Infect Immun. 2022;90(8):e00174-22. DOI: 10.1128/iai.00174-22
10. Alfathi M, Alabdaly Y, Al-Hayyali F. Ameliorative effect of spirulina against gentamicin toxicity in liver and kidney tissues of male rat. Egypt J Histol. 2023;46(4):1666-1675. DOI: 10.21608/ejh.2022.155247.1750
11. Pouget JP, Constanzo J. Revisiting the radiobiology of targeted alpha therapy. Front Med. 2021;8:692436. DOI: 10.3389/fmed.2021.692436
12. Zhang J, Chen Z, Shan D, Wu Y, Zhao Y, Li C, Shu Y, Linghu X, Wang B. Adverse effects of exposure to fine particles and ultrafine particles in the environment on different organs of organisms. J Environ Sci. 2024;135:449-473. DOI: 10.1016/j.jes.2022.08.013
13. Al-Ebady EQ. Effect of food host type, exposure time in responsibility of different stage of *Trogoderma granarium* Everts khabra beetle F of microwave radiation under storage in bags. Mesopotamia J Agric. 2020;84(1):2224-9796. DOI: 10.33899/magrj.2020.126463.1020
14. Wadhwa A, Moreno-Villanueva M, Crucian B, Wu H. Synergistic interplay between radiation and microgravity in spaceflight-related immunological health risks. Immun Ageing. 2024;21(1):50. DOI: 10.1186/s12979-024-00449-w
15. Smyth J, Barrett N. Procedures for testing the viability of human hydatid cysts following surgical removal especially after chemotherapy. Trans R Soc Trop Med Hyg. 1980;74(5):649-652. DOI: 10.1016/0035-9203(80)90157-1
16. Smyth J. In vitro culture of *Echinococcus* spp. Proceedings of the 13th Int Congr Hydatidol. Madrid. 1985;85:84-89. doi: 10.1016/0020-7519
17. Cember H. Introduction of health physics. 3rd ed. UK: Pergamon Press; 1996. 129-131 p.
18. Alturkistani HA, Tashkandi FM, Mohammedsaleh ZM. Histological stains: a literature review and case study. Global J Health Sci. 2016;8(3):72. DOI: 10.5539/gjhs.v8n3p72
19. Kroeze WK, Tanner CE. Echinococcus multilocularis susceptibility and responses to infection in bred mice. Int J Parasitol. 1987;17(4):873-83. DOI: 10.1016/0020-7519(87)90003-8

20. El-Lehleh AM, Algamal AA, El-Shazly RA, ElMezain EF. Study of serum endotoxin in patients with liver cirrhosis with and without hepatic encephalopathy. Menoufia Med J. 2019;32(1):363-7. DOI: 10.4103/mmj.mmj-653-17
21. Sheskin DJ. Handbook of parametric and non-parametric statistical procedures. USA: Chapman and Hall/CRC; 2003.
22. Mao RB, Zhang WB, Qi HZ, Jiang T, Wu G, Lu PF, Shang G, Xu L, Hao J, Shou X, Li H, Li J, Zhang S, Bao Y, Wen H. Efficacy of radiotherapy for the treatment of cystic echinococcosis in naturally infected sheep. Infect Dis Poverty. 2017;6:88. DOI: 10.1186/s40249-017-0301-7
23. Kaur AP, Alice A, Crittenden MR, Gough MJ. The role of dendritic cells in radiation-induced immune responses. Int Rev Cell Mol Biol. 2023;378:61-104. DOI: 10.1016/bs.ircmb.2023.02.002
24. De Biase D, Prisco F, Pepe P, Bosco A, Piegari G, d'Aquino I, Russo V, Papparella S, Maurelli MP, Rinaldi L, Paciello O. Evaluation of the local immune response to hydatid cysts in sheep liver. Vet Sci. 2023;10(5):315. DOI: 10.3390/vetsci10050315
25. Razian Y, Shaki P, Rashidipou M, Cheraghipou K, Ghasemian Yadegari J, Mahmoudvand H. Green synthesis, characterization, and antiparasitic effects of gold nanoparticles against Echinococcus granulosus protoscoleces. Trop Med Infect Dis. 2023;8(6):313. DOI: 10.3390/tropicalmed8060313
26. Abdulkadhim HA, Al-Mayali HH. Molecular characterizations of *Echinococcus granulosus* isolated from human and sheep in Euphrates region of Iraq. Int J Pharm Res. 2020;12(1):2296-303. DOI: 10.31838/ijpr/2020.SP1.347
27. Florentino PT, Mendes D, Vitorino FNL, Martins DJ, Cunha JP, Mortara RA, Menck CF. DNA damage and oxidative stress in human cells infected by Trypanosoma cruzi. PLoS Pathog. 2021;17(4):e1009502. DOI: 10.1371/journal.ppat.1009502
28. Wang Y, Su M, Chen Y, Huang X, Ruan L, Lv Q, Li L. Research progress on the role and mechanism of DNA damage repair in germ cell development. Front Endocrinol. 2023;14:1234280. DOI: 10.3389/fendo.2023.1234280
29. Nikitaki Z, Nikolov V, Mavragani IV, Mladenov E, Mangelis A, Laskaratou DA, Fragkoulis GI, Hellweg CE, Martin OA, Emfietzoglou D, Hatzi VI. Measurement of complex DNA damage induction and repair in human cellular systems after exposure to ionizing radiations of varying linear energy transfer. Free Radic Res. 2016;50(1):S64-78. DOI: 10715762.2016.1232484
30. Kamiya K, Ozasa K, Akiba S, Niwa O, Kodama K, Takamura N, Zaharieva EK, Kimura Y, Wakeford R. Long-term effects of radiation exposure on health. Lancet. 2015;386(9992):469-78. [available at]
31. Burgio E, Piscitelli P, Migliore L. Ionizing radiation and human health: reviewing models of exposure and mechanisms of cellular damage—an epigenetic perspective. Int J Environ Res Public Health. 2018;15(9):1971. DOI: https://doi.org/10.3390/ijerph15091971
32. Szewczyk-Golec K, Pawłowska M, Wesołowski R, Wróblewski M, Mila-Kierzenkowska C. Oxidative stress as a possible target in the treatment of toxoplasmosis: perspectives and ambiguities. Int J Mol Sci. 2021;22(11):5705. DOI: 10.3390/ijms22115705
33. Eissa MM, Salem AE, El Skhawy N. Parasites revive hope for cancer therapy. Eur J Med Res. 2024;29(1):489. DOI: 10.1186/s40001-024-02057-2
34. Ilderbayev O, Okassova A, Rakhyzhanova S, Ilderbayeva G, Zhazykbayeva L. The levels of oxidative stress in a combination of stress factors. J Med Life. 2022;15(8):927. DOI: 10.25122/jml-2021-0060
35. Benchabane S, Sour S, Zidi S, Hadjimi Z, Nabila L, Acheli D, Bouzenad A, Belguendouz H, Touil-Boukoffa C. Exploring the relationship between oxidative stress status and inflammatory markers during primary Sjögren's syndrome: a new approach for patient monitoring. Int J Immunopathol Pharmacol. 2024;38:45. DOI: 10.1177/03946320241263034
36. Lu L, Li F, Gao Y, Kang S, Li J, Guo J. Microbiome in radiotherapy: an emerging approach to enhance treatment efficacy and reduce tissue injury. Mol Med. 2024;30(1):105. DOI: 10.1186/s10020-024-00873-0
37. Al-Jammas S, Al-Allaf LIK, Saeed MG. Attenuating effects of α-tocopherol on cytarabine-induced toxicity in parotid salivary gland of rabbits: a histological and immunohistochemical study. Iran J Vet Med. 2024;18(1):33-42. DOI: 10.32598/ijvm.18.1.1005352
38. Grosu-Bularda A, Lita FF, Hodea FV, Bordeanu-Diaconescu EM, Cretu A, Dumitru CS, Cacior S, Marinescu BM, Lascar I, Hariga CS. Navigating the complexities of radiation injuries: therapeutic principles and reconstructive strategies. J Pers Med. 2024;14(11):1100. DOI: 10.3390/jpm14111100
39. Ren J, Zhuo Y, He F, Lv L, Xing M, Guo Y, Zhang Y, Liu J, Li Y, Bai T, Chen Y. Longitudinal immune profiling highlights CD4+ T cell exhaustion correlated with liver fibrosis in Schistosoma japonicum infection. J Immunol. 2023;210(1):82-95. DOI: 10.4049/jimmunol.2200301
40. Abdulrazaq Omar M, Alabdaly YZ. Effect of alkaline drinking water on vitamin D3 toxicity in female rats. Egypt J Vet Sci. 2023;54(1):109-16. DOI: 10.21608/EJVS.2022.152903.1372
41. Sellau J, Hansen CS, Gálvez RI, Linnemann L, Honecker B, Lotter H. Immunological clues to sex differences in parasitic diseases. Trends Parasitol. 2024;40(11):1037-49. DOI: 10.1016/j.pt.2024.09.006

تأثير الإشعاع النووي في تعبير عنقود التمايز الرابع باستخدام السمات الكيميائية النسجية المناعية في بعض أعضاء الجرذان المصابة بالمشوكات الحبيبية وتقييم أنزيمات الكبد

سهيلة يعقوب يوسف[1]، أميمة عادل نجم[1] و ياسر يحيى قاسم[2]

[1]قسم علوم الحياة، [2]قسم الفيزياء، كلية التربية للعلوم الصرفة، جامعة الموصل، الموصل، العراق

الخلاصة

يعد داء المشوكات الكيسي من المشاكل الصحية الواسعة الانتشار في جميع أنحاء العالم والذي تسببه دودة المشوكات الشريطية. يهدف البحث الحالي الى الكشف عن تأثير الجسيمات النووية على مستويات تعبير بروتين عنقود التمايز الرابع في أعضاء الجسم (الكبد، الطحال والأمعاء) والأنزيمات المرتبطة بوظائف الكبد كلوتاميت بايروفيت ترانس امينيز، كلوتاميت اوكزالواسيتيت ترانس امينيز والفوسفاتاز القاعدي في الجرذان المصابة بداء الأكياس العدرية. تم الحصول على عينات الأكياس العدرية والرؤيسات الاولية من أكباد الأغنام وتم تقدير حيوية الرؤيسات الأولية. عرّضت الرؤيسات الأولية الى طاقات مختلفة من الجسيمات النووية وفترات زمنية مختلفة لدراسة حيويتها بعد التعريض، ثم حقنت الرؤيسات الأولية، المعرضة للجسيمات النووية وغير المعرضة، بستة مجاميع من الجرذان وتم مراقبة التأثيرات في أعضاء الجرذان من الناحية الفسلجية والكيمياء الحياتية وعلى مدى فترات زمنية مختلفة. تشير نتائج الحالية الى أن فترات التعرض الأطول للرؤيسات الأولية الى الجسيمات النووية أدى الى زيادة نسبة قتلها، كما لوحظ أن أوزان الكبد والطحال ومعامل تضخمهما تعود الى المستويات الطبيعية بعد خمسة أشهر فضلاً عن أن مستويات أنزيمات الكبد بقيت ضمن النطاق الطبيعي بعد أربعة وخمسة أشهر من الاصابة. ساهم التعرض الطويل للجسيمات النووية في القضاء على الطفيل وتعافي الأنسجة. يسلط البحث الحالي الضوء على إمكانية استخدام الجسيمات النووية كعلاج لداء الأكياس العدرية من خلال التأثير على معدل بقائها.