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STUDY THE EFFECTS OF INHALATION OF TSKALTUBO MINERAL-RADON WATERS ON EXPERIMENTAL ANIMALS

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Abstract:

Radon balneotherapy is a traditional approach involving the use of radon sources for balneological procedures. Despite numerous studies on the impact of radon on the body, the safety of using radon for medical purposes remains uncertain. While there is a clearly defined upper limit of the dose rate to achieve a radioadaptive response, the lower limit for this hormetic effect is still inconclusive. Current beliefs suggest that the minimum effective therapeutic radon concentrations are as follows: 200 Bq/l for water baths and 700 Bq/l for inhalation of radon and its products. However, in laboratory rat studies, hormetic responses were observed at significantly lower doses of radon exposure (37 Bq/m^3). To address this issue, we conducted experiments on laboratory rats, exposing them to a continuously dosed radon exposure not exceeding 50 Bq/m^3. The level of inhalation-assimilated radon over 3 months was determined by measuring the presence of one of its decay products, lead-210, in flat bones. This radioisotope was analyzed using a Canberra gamma spectrometer equipped with a highly sensitive germanium detector. The results obtained indicated that at such a level of radon exposure, the hormetic response could not be attributed to radiation-induced effects.

Keywords: radon, gamma-irradiation, hormesis, Tskaltubo.

INTRODUCTION

Radiation safety concerns are quite important, as the use of new gadgets and technology that rely on radiation in medical therapy and diagnostics is increasing year over year [1, 5, 20]. This has made it necessary to revise outdated protocols and conduct safety evaluations of the radiation technologies used in modern medicine. The safety assessment of radon-mineral water treatments at medical spas is very significant in this regard. Recent research findings indicate that Tskaltubo waters have a significant hormesis effect [3, 15]. The results obtained from analyzing the physiological, biochemical, and other parameters of these

waters are attributed to the effects solely induced by the radon content, as discussed in scientific publications [16, 18]. According to the international classification, healing mineral waters are categorized into four main groups: radon, radium, radon-radium, and uranium. Radon waters serve medicinal purposes. Based on radioactivity levels, radon waters can be categorized as follows: weak radon waters, with radon concentrations ranging from 200 to 1500 becquerels per liter (Bq/L); waters with a moderate radon concentration, ranging from 1500 to 7500 Bq/L; and high-radon waters, with radon concentrations exceeding 7500 Bq/L. The minimum effective concentration for radon treatment is considered as follows: 200 becquerels per liter (Bq/L) for water baths and 4000 Bq/L for drinking. The impact of a radioactive radiation assessment is based on the dose absorbed by the body. The maximum allowable radiation dose for a patient during the treatment course is as follows: 34,000 Bq/L for water baths, 9400 Bq/L for airborne exposure, and 700 Bq/L for the inhalation of radon and its by-products. Publications have indicated a dose of 37 becquerels per cubic meter (Bq/m³) during inhalation [2, 4, 13, 14, 17, 19]. Employing such a low dose poses a potential health risk for the patient, as the smaller the hormesis dose of irradiation, the lower the critical (damaging) dose, depending on the overall radioresistance of the body [9]. Therefore, there is a compelling need for research focused on the safety aspects of radon exposure. The objective of this paper is to assess the accuracy of the statement that attributes the hormesis level of Tskaltubo mineral waters solely to their radon content. As the observed effects are not specific to radiation, it is essential to explore the contribution of radon radiation effects when employing multi-component water.

MATERIAL AND METHODS

The subject of the research comprised laboratory white rats, exposed to controlled radon irradiation for three months. The control group, comprising 10 laboratory white rats, and the test group, also comprising 10 laboratory white rats, underwent testing three times each. To ensure a consistent level of radon radiation, aerated water (with a total reservoir capacity of three tons) was employed. Continuous monitoring of air radon saturation was carried out using a radonometer (Airthings Digital Radon Detector). Throughout the experiment, the laboratory animals were housed in a warm environment with 80% humidity. Upon the conclusion of incubation, dried and crushed tissues from the flat bones of experimental animals were employed as the marker object. Given the rapid nuclear decay stages experienced by radon, the utilization of a long-lived isotope, 210Pb, representing an intermediate decay product in the radon transformation process was conducted to achieve relatively consistent rates of radon incorporation into a living organism. The quantitative determination of the lead isotope was executed using a gamma-spectrometer (Canberra) equipped with a germanium detector, which possesses a freezing temperature of -196°C. Subsequently, the acquired spectra were analyzed employing the "Genius-2000" program.

The localization effect of one of the radon decay products (-210Pb) was used in our study to establish a cause-and-effect relationship between the dose of radon absorbed by a living organism and the initiation of the process of radiohormesis. The 210Pb isotope that we used has an increased half-life (22.3 years) in the radon decay series (222Rn-218Po-214Pb-214Bi-214Po-210Pb). Unlike other isotopes in this series, the increased half-life of 210Pb makes it suitable for use as a marker for assessing the degree of radon infiltration into the body [7, 8]. Lead is characterized by the property of stable accumulation in bone tissue, which makes it a constant source of increased levels of lead in the blood even after the cessation of external exposure [10]. This characteristic allows one to calculate the lead content in bones and serves as the only reliable indicator of body contamination with this element. If blood as a dynamic system reflects the direct influence of lead on the body [6], then the peculiarity of the accumulation of the

element, along with its concentration in depositing tissues, characterizes the persistence and duration of its penetration into the body [11, 12]. Therefore, the radioactive lead content serves as a suitable indicator for studying the penetration of radon into body tissues and its conversion to radioactive lead.

RESULTS AND DISCUSSION

The indicators of the dose of radon absorbed by rats obtained in the work are of great importance for assessing the potential risks to the health of patients during radon therapy with Tskaltubo geothermal waters. This phenomenon is substantiated by the above-mentioned scientific studies carried out in Georgia, which highlight the radiohormetic effect of Tskaltubo waters caused by radon.

In the research, the gamma-spectrometric analysis method was employed to determine radioactive lead in the environmental continuum and the flat bones of the test animals. As observed in the data presented in the first image, the environmental continuum exhibited a radioactivity level of approximately 1160–1170 pulses, resulting in a pure signal of 268–278 pulses (1438–1160, 1170). Similar indicators of radioactivity were noted in the gamma-spectrum fragments of the flat bones of experimental animals. Consequently, the radioactive spectrum exhibited uniform characteristics in both scenarios, indicating that no additional activity of the lead isotope was detected in the test variant within the radioactive lead localization zone (46.5 keV). This suggests that the quantitative assessment of radon absorbed by the animals utilized in the experiment approximates the background (reference) rate. (Fig.1).

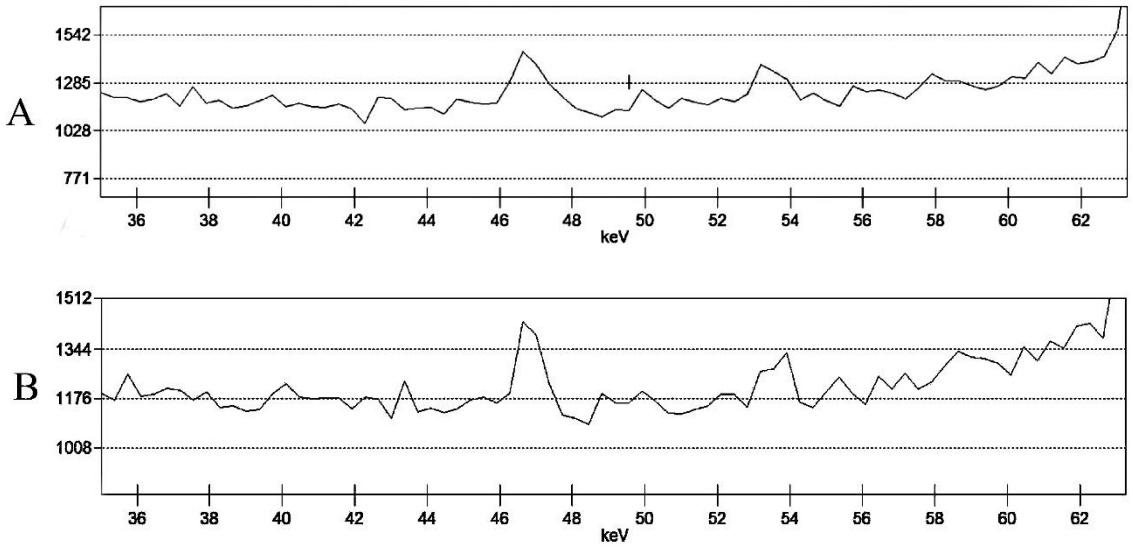

Figure 1. The fragments of the gamma spectra of the environmental continuum and the radioactivity of the flat bones of test animals in the radioactive lead localization zone (46.5keV).
Note: A represents the fragment of the gamma spectrum of the continuum, while **B** represents the fragment of the gamma spectrum of flat bones.

Our results showed that radiation-induced effects could not be the cause of the hormetic reaction at this level of radon exposure. Consequently, the observed hormetic effect on various physiological parameters in laboratory rats [4, 18] manifests not only as a consequence of radon exposure. This situation arises because, in the region of low doses, aside from the linear dose response, other forms of dose dependence are equally probable. Therefore, it becomes challenging to isolate the radiation-induced effect due to the interference of non-radiation

factors. One plausible explanation for the therapeutic effect observed during inhalation could be the influence of ionic and gaseous constituents present in mineral water and moist heat. The inhaled, sprayed water affects the reflexogenic areas of the respiratory tract, transmitting impulses to the central nervous system, which then impacts the body. In this case, the contribution of radiation exposure is minimal, making it inappropriate to classify this effect as radio-hormesis. That is, the activation of physiological and biochemical processes (hormesis) is caused not only by the dose of radon absorbed by the body but also by the combined effect of various factors. Further research is needed to explore these factors.

CONCLUSION

Based on the analysis of the obtained results, it can be concluded that the effect of radio-hormesis observed in the given interval of radon irradiation dose, among numerous influencing physicochemical factors, is not solely the outcome of the radon component's influence.

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ИЗУЧЕНИЕ ЭФФЕКТА ИНГАЛЯЦИЙ МИНЕРАЛЬНО-РАДОНОВЫХ ВОД ЦХАЛТУБО НА ЭКСПЕРИМЕНТАЛЬНЫХ ЖИВОТНЫХ

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Радоновая бальнеотерапия – традиционный метод, предполагающий использование источников радона для бальнеологических процедур. Несмотря на многочисленные исследования влияния радона на организм, безопасность использования радона в медицинских целях остается неопределенной. Имеются четко определенные данные относительно верхнего предела мощности дозы для достижения радиоадаптивного ответа, а нижний предел данного эффекта все еще неясен. Согласно современным представлениям, минимальные эффективные терапевтические концентрации радона составляют: 200 Бк/л для водяных бань и 700 Бк/л для вдыхания радона и его продуктов. Однако в лабораторных исследованиях на крысах горметические реакции наблюдались при значительно меньших дозах воздействия радона (37 Бк/м3). Для решения этого вопроса мы провели эксперименты на лабораторных крысах, подвергая их непрерывному дозированному облучению радоном, не превышающему 50 Бк/м3. Уровень ингаляционно-ассимилируемого радона в течение 3 месяцев определяли путем измерения наличия в плоских костях одного из продуктов его распада - свинца-210. Этот радиоизотоп анализировали с помощью гамма-спектрометра Canberra, оснащенного высокочувствительным германиевым детектором. Полученные нами результаты показали, что при данном уровне воздействия радона горметическую реакцию нельзя объяснить радиационно-индуцированными эффектами.

Ключевые слова: радон, гамма-облучение, гормезис, Цкалтубо.

TSXALTUBO MİNERAL RADON SULARININ İNHALYASİYASININ EKSPERİMENTAL HEYVANLARA TƏSİRİNİN ÖYRƏNİLMƏSİ

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Radon balneoterapiyası balneoloji prosedurlar üçün radon mənbələrindən istifadəni nəzərdə tutan ənənəvi üsuldur. Radonun orqanizmə təsiri ilə bağlı çoxsaylı araşdırmalara baxmayaraq, radonun tibbi məqsədlər üçün istifadəsinin təhlükəsizliyi qeyri-müəyyən olaraq qalır. Radioadaptiv reaksiyaya səbəb olan dozanın yuxarı həddi ilə bağlı dəqiq müəyyən edilmiş məlumatlar mövcud olsa da, bu təsirin aşağı həddi hələ də məlum deyildir. Müasir konsepsiyalara görə radonun minimum effektiv terapevtik konsentrasiyası belədir: su vannaları üçün 200 Bq/l, radon və onun məhsullarının inhalyasiyası üçün 700 Bq/l. Bununla belə, siçovullar üzərində aparılan laboratoriya tədqiqatlarında əhəmiyyətli dərəcədə aşağı dozalarının (37 Bq/m3) təsirinə məruz qaldıqda hormetik reaksiyalar müşahidə edilmişdir. Bu problemi həll etmək üçün biz laboratoriya siçovullarını 50 Bq/m3-dən çox olmayan davamlı dozada radon şüalanmasına məruz qoyaraq təcrübələr apardıq. 3 ay ərzində tənəffüs yolu ilə mənimsənilən radonun səviyyəsi yastı sümüklərdə onun parçalanma məhsullarından biri olan qurğuşun-210-un mövcudluğunu ölçməklə müəyyən edilmişdir. Bu radioizotop yüksək həssas germanium detektoru ilə təchiz edilmiş Kanberra qamma-spektrometrindən istifadə edərək təhlil edilmişdir. Nəticələrimiz göstərdi ki, verilmiş səviyyədə radona məruz qalma nəticəsində yaranan hormetik reaksiya radiasiyanın səbəb olduğu təsirlərlə izah edilə bilməz.

Açar sözlər: radon, qamma-şüalanma, hormesis, Tskaltubo.

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