The effect of drinking water mineral composition on the small intestine morphology of white rats

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ABSTRACT

A comparative study was carried out to evaluate the influence exerted by ion balanced drinking water, faucet water with a high content of fluorine, iron, calcium and magnesium and sodium chloride water on the morphology and morphometric characteristics of the small intestine of pregnant and non-pregnant female white rats. The results showed that sodium chloride water has the most pronounced negative effect on the morphological and morphometric characteristics of the small intestine of experimental animals.

INTRODUCTION

Among the reasons that affect human health, the properties of water consumed have a certain value [1, 2]. The problem of providing the population with drinking water of high quality is socially important because it directly affects the human health.

Water is the unifying component of all biological fluids and soft tissues of the body. The water exchange is closely related to the electrolyte exchange. Water entering the body is not in its pure form but with dissolved substances [3].

The study of the role of the gastrointestinal tract in maintaining balance of the most important intracellular cations in the body has shown that the small intestine is the main place of the digestive system where the cation excretion is adjusted. It has the ability to adjust to environmental conditions, as the water and nutrients received from the outside directly contact with it [4, 5, 6].

Taking into account the importance of the small intestine as part of the digestive system, which directly provides the contact with water, a comparative study of the impact of the faucet water with a high content of iron, calcium, magnesium, fluoride ions and chloride-sodium water consumption on structural and functional state of the small intestine of pregnant and non-pregnant laboratory rats has been undertaken.

Methods:

In our work, we used produced artesian water with a high content of fluorine, iron, calcium and magnesium that determined its increased stiffness; sodium chloride water (sodium hypertonic solution), as well as bottled drinking water "Aqua Minerale" with balanced ionic composition.

As biological test object we used white adult female rats weighing 180-200 g. In total, 60 animals were used. Subject to the set task the animals were divided into groups.

The first (control) group consisted of non-pregnant females that consumed packaged non-carbonated drinking water "Aqua Minerale" with balanced content of micro- and macro elements.

The second (experience 1) group consisted of pregnant rats that consumed drinking water "Aqua Minerale.

The third (experience 2) group consisted of non-pregnant rats that consumed drinking water with increased concentration of iron, calcium, magnesium and fluoride from the central water system.

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The fourth (experience 3) group included pregnant rats consuming faucet water with a high content of iron, calcium, magnesium and fluorine.

The fifth (experience 4) group consisted of non-pregnant rats drinking sodium chloride water.

The experiment was conducted in the summer-autumn period, indoors at the temperature of 22-25ºC and relative humidity of 67-70%. The animals were kept in the common mode of the vivarium and had free access to food and water. Pregnancy was established determining the mating time of females that were in heat. The animals were considered pregnant since the morning of the day when the vaginal contents showed sperm. The animals were slaughtered on the 21-st day of the experiment by decapitation under anesthesia with ether and chloroform in compliance with the principles of humanity set out in the directives of the European Community (86/609/EEC) and the Declaration of Helsinki and in accordance with the rules of work with experimental animals.

In order to examine morphological changes in the animals that were consuming the drinking water "Aqua Minerale", the faucet water with a high content of iron, calcium, magnesium and fluorine, and hypertonic solution of sodium chloride the pieces of jejunum 10x10 mm in size were studied. For histological examination the material was fixed in 10% neutral formalin solution. The fixed samples after rinsing in running water were dehydrated by placing the test material in alcohols of increasing concentration and embedded in paraffin by common method. The histological sections 7-10 µm thick were prepared, H&E stained according to Van Gieson and examined using a digital microscope Axio Imager.M2 (ZEISS, Japan) with the software for image analysis AxioVision SE64 Rel. 4.8.3 and ZEN 2011.

While studying the small intestine (jejunum), the thickness of the whole intestinal wall, mucous and muscular membranes, the height and width of the villi, the depth and width of the crypts, the area of the enterocytes and their nuclei villi and crypts, the number and area of goblet cells were determined.

The statistical processing of the digital data was carried out using FStat and Exel. The statistical hypothesis testing was carried out by Student t-test. In assessing the statistical hypotheses the following levels of significance were made: p ≤ 0.05.

The main part:

The consumption of the drinking water "Aqua Minerale" by non-pregnant (control) and pregnant animals (experience 1) has not revealed any differences in the wall thickness of the intestine mucous membrane (Fig. 1).

The histological studies of the mucous membrane of pregnant animals (experience 1) consuming drinking water "Aqua Minerale" have shown that it does not differ from that of non-pregnant animals (control). Pathological disorders indicating inflammation, atrophy or necrosis have not been observed. However, a slight increase in the area of the villus enterocytes by 12.96% (P ≤ 0.05) and crypts - by 13.52% (P ≤ 0.05) has been revealed (Fig. 1 and 2).

The consumption of water with an increased content of iron, calcium, magnesium and fluorine by non-pregnant rats (experience 2) has contributed to the increase in the small intestinal wall thickness by 29.66% (P ≤ 0.05) mainly due to the mucosa, which has increased by 43.88% (P ≤ 0.05) as compared to the control.

The histological studies have shown the presence of mucus with inclusions of cast-off epithelial layers, single lymphocytes in the intestinal lumen and between the villi. At the villi bottom and in the crypts mouths the number of goblet cells is higher than in the control, indicating the functional activity of the goblet-cell apparatus.

An increase in the small intestinal wall thickness by 18.5% (P≤0.05) as well as an increase in the thickness of mucosa by 16.67% (P≤0.05) when pregnant animals (experience 3) use the faucet water have been determined as compared to the control.

The histological examination of the mucous membrane of the pregnant animals’ jejunum has marked a decrease in villus height by 17.0% (P≤0.05) (experience 3) as compared to non-pregnant animals (experience 2) consuming faucet water, which can be explained by an increase in the process of desquamation of enterocytes of the villus apical part. At the same time an increase in villi exocynocytes height, the area of their nucleus, the area of the crypts, indicating the activation of myxopoiesis in the cell has been determined. At the villi bottom, an increase in the number of goblet cells by 14.3% (P≤0.05) has been determined as compared to the control. This can be estimated as a protective reaction of myxopoiesis enhancement by the small intestine epithelium to the increased in time flow of water with unusual for the animal composition in its clearance, which does not contradict the available data [7, 8, 9, 10].

The consumption of 1.0% solution of sodium chloride (experience 4) by non-pregnant animals has shown a significant decrease in the thickness of muscular and mucous membranes by 29.25% (P≤0.05) and 48.35% (P≤0.05) respectively as compared to the controls.

The histological studies of the jejunum wall of the white non-pregnant rats that consumed 1.0% solution of sodium chloride (experience 4) have shown a reduction of intestinal villi length by 18.24% (P≤0.05), an-
crease in the crypts width by 25.62% (Р≤ 0.05), the reduction of the area of villus nuclei enterocytes by 28.98% (Р≤ 0.05), the increased number of goblet cells by 78.63% (Р≤ 0.05) as compared to the control.

The thickness of small intestinal wall of pregnant white rats consuming "Aqua Minerale", faucet water with high stiffness and sodium chloride water in an unlimited amount did not differ significantly from its value with non-pregnant rats (experience 4). The histology has shown that there is much mucus with the inclusions of cast-off epithelial layers in the intestinal lumen and between the villi. A pronounced polymorphism of the intestinal villi in diameter, shape, and length has been marked.

These changes are considered to be a manifestation of the epithelium response to the negative nonspecific effects of hypertonic solution of sodium chloride, allowing us to speak of its negative effect on the jejunum walls.

**Summary:**

The analysis of the literature indicates that the effect of drinking water with a high content of iron, calcium, magnesium and fluorine on the morphology of the small intestine has not been studied sufficiently. The effect of sodium chloride water on the morphology of the small intestine is not clear, either.
The study has found that the faucet water with a high content of iron, calcium, magnesium and fluoride is not a strong stressful factor for non-pregnant rats. It rather can be classified as a "low-intensity factor", under a long-term impact of which no qualitative changes at the cellular-tissue levels are observed. This factor has had a stronger impact on the body of the pregnant animals.

It has been found that sodium chloride water has a more significant effect on the morphology of the jejunum wall of non-pregnant and pregnant white rats, which is manifested in the pronounced polymorphism of the diameter, shape and length of intestinal villi, in the presence of large amounts of mucus with inclusions of cast-off epithelial layers in the intestinal lumen and between villi.

These changes are the manifestation of the epithelium and the whole intestinal wall reaction to the adverse, non-specific effect of hypertonic solution of sodium chloride.

Conclusions:
1. The consumption of faucet water with a high content of iron, calcium, magnesium and fluorine causes an adaptive response at the tissue and cellular level of the white rats’ small intestine.
2. Sodium chloride water has a significant effect on the morphology of the non-pregnant and pregnant white rats’ jejunum wall. The detected changes are considered to be a manifestation of the epithelium response to the negative nonspecific effects of this water, allowing us to speak of its negative effect on the jejunum walls.

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