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Effect of a water-rich diet on adrenal zona glomerulosa in *Gerbillus tarabuli*

Effet d'un régime riche en eau sur la zone glomérulée surrénalienne chez Gerbillus tarabuli

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ABSTRACT

The objective of this work is to evaluate the aldosterone level and to study the gerbil adrenal zona glomerulosa morphology in the presence of an important water diet content during seven days. Thirty adult gerbils, *Gerbilus tarabuli*, were randomly assigned to two watering regimes, with fifteen gerbils per group. The first group was the control and the second group was exposed to a water-rich diet during seven days. Thin sections of the adrenal glands were observed in photonic and electron microscopy. Their blood was sampled and analyzed for aldosterone, electrolyte concentrations and hematocrit. Urine was collected after 24 hours. A water-rich diet decreased the body weight but increased the hematocrit, total protein, aldosterone concentration and urine volume. In electronic microscopy, the adrenal zona glomerulosa cells present a decrease in lipid compartment and Golgi apparatus zone development. The blood electrolyte concentrations were not changed significantly. These findings indicate that the water-rich diet exerts a potent stimulatory effect on aldosterone secretion by the gerbil adrenal zona glomerulosa through plasma volume perturbation.

Mots clés :
Gerbillus tarabuli
Perturbation
Régime riche en eau
Zone glomérulée surrénalienne
Aldostérone

RÉSUMÉ

L'objectif du présent travail et d'évaluer le taux plasmatique de l'aldostérone et d'étudier la morphologie de la zone glomérulée surrénalienne en présence d'un apport important d'eau alimentaire, pendant sept jours, chez *Gerbillus tarabuli*. Trente gerbilles adultes sont réparties en deux groupes de quinze gerbilles par groupe. Le premier groupe constitue le control et le second est exposé à un régime riche en eau durant sept jours. Les coupes fines de la glande surrénale sont observées aux microscopes photoniques et électroniques. Le sang est destiné au dosage de l'aldostérone, des électrolytes et de l'hématocrite. Les urines sont collectées après 24 heures. Le régime riche en eau décroît le poids corporel mais augmente l'hématocrite, la concentration des protéines totales et de l'aldostérone et le volume urinaire. En microscopie électronique, les cellules glomérulées présentent une régression du compartiment lipidique et le développement de Golgi. La concentration plasmatique des électrolytes n'a pas changé significativement. Ces résultats indiquent que le régime riche en eau exerce un puissant effet stimulateur sur la sécrétion de l'aldostérone par la zone glomérulée surrénalienne de la gerbille via la perturbation du volume plasmatique.

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1. Introduction

Diet constitutes an important source of water in desert environments. Both food selection with a high water content and renal adaptations are mechanisms for water ingestion and conservation where its availability is limited [1,2]. Rodents are considered highly suitable animals for raising in arid and desert regions. They are able to survive on a dry diet and may go into a state of dehydration for a long period during the dry summer season [3]. These small mammals have developed different combinations of ecological, anatomical, behavioural and physiological adaptation strategies that enable them to survive under these conditions of extreme heat and water stress [4,5]. Several reports have documented that the rodent kidney and colon have developed morphological adaptations, which give them the opportunity to deliver highly concentrated urine [2,6–8]. Activity of both organs is controlled by the hormonal system including vasopressin and aldosterone, which are the main hormones involved [9,10]. Various research programmes have shown that the desert rodents have a high rate of vasopressin and aldosterone, that allows them a great water and electrolyte reabsorption through the renal tubule and gastrointestinal reservoir [3,4,11,12]. Aldosterone, a major mineralocorticoidal hormone, stimulates the transcription of genes encoding Na^+/K^+ ATPase, sodium channels and increases their numbers at the basolateral membranes and the epithelium of the collecting duct, distal tube and the ascending limb of loop of Henle, thus, minimizing urinary Na^+ and water output [13–15].

In rodents adapted to water deprivation, the water economy is the result of the complementary action of vasopressin and aldosterone on the kidney. High levels of plasma aldosterone promote significant Na^+ reabsorption in the kidney and a gradient corticopapillar rise, which increases water reabsorption in the presence of a high level of vasopressin [16]. Aldosterone is essentially synthesized in the adrenal zona glomerulosa [17–19], whose cells have the ability to adapt their morphology to environmental conditions [20–22].

Chatelain et al. [20] showed that in dehydrated adult female rats suffering water deprivation for three days, the adrenal zona glomerulosa cells present hyperplasia and a rise in aldosterone secretion. Moreover, from eight days of water deprivation, the plasma aldosterone level increased in *Merion shawi*. This level increased even more after 30 days [16]. In *Gerbillus campestris*, the level of plasma aldosterone increased under a dry diet [23]. According Sellami et al. [16], in rodents, the increase level of aldosterone in response to water deprivation seems to be a desert adaptive feature.

Gerbillus tarabuli, a nocturne rodent, inhabits arid and semi-arid localities in Algeria, Tunisia, Morocco, Senegal, Mauritania, Niger and Tchad [24–29]. It is well adapted to water scarcity and presents a large capacity to maintain hydromineral balance under water restriction during a long period [30,31]. *G. tarabuli* can survive exclusively on a dry diet and be independent of exogenous water. It is marked by a lack of sweat glands, excretion of highly concentrated urine and a significant production of metabolic water [32,33].

The objective of this work is to evaluate the aldosterone level and to study the gerbil adrenal zona glomerulosa morphology in the presence of an important water diet content during seven days.

2. Materials and methods

2.1. Animals

Thirty adult male and female gerbils (*G. tarabuli),* weighing between 32 and 53 g, from the Algerian Arid Zones Station were maintained under a controlled temperature (25 °C) and relative humidity (20–25%) with a 14 h photoperiod. The animals were given barley and dates ad libitum. Water has not been supplied. Gerbils were acclimatized for 48 h prior to the start of the experiment. Animal manipulations were performed according to the recommendations of the Algerian ethical committee and under the supervision of authorized investigators.

2.2. Experimental design

The animals are housed in large cages equipped with a metal lid and filled in 1/4 with sand from the *Beni Abbes* region. Each cage contained five adult male and female gerbils. Gerbils were divided into two groups. The first group ($n = 15$) served as controls. The gerbil controls were given barley grain (100 g containing: 10.4% water; 9.6% protein; 50.3% sugar; 50.3% cellulose; total mineral content: 2.7%) and dry dates (100 g containing: 15% water; 2.5% protein; 69% sugar; total mineral content: 1.5 to 1.8 g; 7 g fiber) ad libitum. The second group ($n = 15$) was given barley, dates and of fresh lettuce leaves (100 g containing: 95% water; 1.7 g protein; 2% sugar; total mineral content: 2 to 2.6 g: 1% fiber) ad libitum for seven day.

2.3. Body and absolute organ weights

The animals were weighed in the morning of the first day and in the end of experiment using a balance (FKBA-KERN). The adrenal glands were weighed individually with precision balance (Sartorius Talent-Germany).

2.4. Blood sample determination

After light anesthesia with chloroform, the gerbils were scarified by rapid decapitation and their blood, collected in heparin, was analyzed for hematocrit, plasma sodium and potassium (NaK radiometer analyser, Copenhagen, Denmark) and for aldosterone concentrations by standard radioimmunoassay [34] (Diagnostic Products, Los Angeles, CA), the sensitivity of which was approximately 31 pmol/l. The within- and between-assay coefficients of variation were 3% and 8%, respectively.