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EFFECT OF ALIMENTRAL FACTORS ON URINE pH

V.P. Stus, N.N. Moiseenko, M.V. Zhbakov, V.V. Ehalov

SI « DMA of the Ministry of Health of Ukraine »

Introduction. Modern medicine is moving towards minimization of invasiveness, improvement and development of prevention of the most common urological diseases that do not involve any surgical intervention. In the development of the most common both urological and general diseases, the alimentary factor is of great importance. It is possible to trace its effect on the body by many laboratory parameters, but this article will talk specifically about the acid-alkaline balance of urine.

The normal environment for the human body is neutral one: the intracellular pH is 6.8, and the blood plasma pH is 7.33 to 7.45. As a result of everyday chemical processes occurring in our body, acidic and alkaline metabolites are formed. In addition, acidic metabolites are formed 20 times more than alkaline metabolites. The body has protective systems aimed primarily at neutralization of acidic decay products and their elimination from the body. Mechanisms for maintaining pH stability are divided into physical-chemical and physiological ones. The acidity of the blood is adjusted in the greatest way, therefore the buffer systems of the blood are the first link of the body's defense against acidity fluctuations. Buffer systems are alkaline and acidic substances that neutralize products and metabolites of the opposite nature that enter the blood [1]. The advantage of buffer systems is the ability to instantly react to pH changes and quickly neutralize a small amount of strong acids and bases. However, the buffer reserves in the blood are quite limited, and due to a strong acid load these reserves begin to be extracted from other organs and tissues, the acidity of which is less critical. Accordingly, in case of a constant acid load, even though the blood pH remains stable, the tissues of other organs undergo pathological acidification causing many chronic diseases. In addition to the fact that buffer systems are able to correct pH shifts limited by their capacity, which is determined by the number of equivalents of a strong acid or base, there is a second drawback of the first line of defense, which lies in its inability to remove metabolic products from the body. In this case, there are second and third physiological lines of defense (respiratory and urinary systems, the liver, gastrointestinal tract, and sweat glands) [2].

The respiratory system is the body's second line of defense against acidity fluctuations. It starts to act 3-12 minutes after the pH drop. The excretion of metabolites occurs quickly, but in case of a strong acid load, the respiratory mechanisms are able to remove only 50-70%, and they are ineffective in case of an excess of alkalis [2].

The mechanisms of the urinary system are the third link in the acidity regulation. In contrast to the buffer and respiratory mechanism, the renal mechanism is not able to affect the pH drop in a short time, but it acts for several days. However, at the same time, up to 500 mmol/day of acids or bases are excreted from the body in the urine, and the urine pH with a strong acid or alkaline load can vary from 4.5 to 8 [3].

In ordinary mixed food and normal drinking regime in a healthy person the excretion of acids exceeds the excretion of bases, therefore urine has a slightly acidic reaction (pH 5.3-6.5) and the concentration of hydrogen ions is about 800 times higher than in the blood. The role of the kidneys in compensating for metabolic and respiratory acidosis is to increase the excretion of hydrogen ions. The kidneys produce and excrete in the urine the amount of hydrogen ions equivalent to their amount continuously entering the plasma from the cells of the body, while replacing the hydrogen ions secreted by the epithelium of the tubules with sodium ions of the primary urine [3]. A stable deviation of urine acidity from the norm can be observed in some urological diseases, such as metabolic disorders, urolithiasis and urothelial tumors [4].

Alimentary factor. The level of acidity of the biological environment of the body is most affected by the diet. All products in the disintegration process form acid and alkaline metabolites.

Human metabolic processes were formed over many centuries and corresponded to different lifestyles at different times.

The history of the nutritional regime of mankind is divided into three large time stages:

- B.C.;
- Agrarian culture;
- Modern humanity.

For most of their lives, humans have been hunters and gatherers. One-third of the diet consisted of low-fat bushmeat and two-thirds of plant products. This diet was completely alkaline, with an average acid load of minus 78 mEq per day.

The situation fundamentally changed with the emergence of an agrarian civilization, when a person began to eat a lot of grain crops, dairy products and fatty meat of domesticated animals [5].

In addition, the regimen of physical activity has changed significantly. Physical activity has a significant effect on urine acidity. After average work intensity, the acidity of urine changed by 0.5 ± 0.67 c.u. towards the oxidation, but after a significant and large load, this figure reached 1.0 + 0.001 c.u. towards oxidation [6]. Thus, the rapid development of civilization has led to abrupt changes in the metabolism formed over millions of years.

The food of modern humans, which has changed especially over the past 20 years and which people began to consume in the last 100 years, does not meet the genetic needs of the body, as it has a sharp acidic character [7]. Moreover, the industrialization of agriculture over the past two centuries has led to significant mineral depletion of soils. As a result, there was not only an imbalance between positively charged ions (anions) and negatively charged ions (cations), but also an imbalance between the cations themselves. If earlier the ratio of K/Na was about 10/1, then the modern diet has a ratio of about 1/3, that is, it has changed 30 times and reversed.

There was also an increase in the chloride/bicarbonate ratio. Edible salt (NaCl), presented in large quantities in our food, only exacerbates the situation. Thus, food ceased to provide the required level of cations and their balance.

Modern food, compared with Paleolithic Ages, is poor not only in potassium, but also in magnesium, as well as dietary fiber, but it is rich in saturated fats, simple sugars, sodium and chlorine.

This contributes to a painful chronic state of acidification of organs and tissues - metabolic acidosis. Unfortunately, acidification of tissues has affected the majority of the population of developed countries, and its degree is increases. What we used to consider natural age-related diseases (urolithiasis, caries, osteoporosis, gout) often turns out to be the direct consequences of mineral depletion [7].

Fundamental factor. At the beginning of the 21st century, a study of the human diet was carried out in America. The another characteristic of food, important from the point of view of health, has been found in this study (in addition to calorie content, saturation with proteins, carbohydrates, fats and vitamins) [8].

Net acid excretion (NAE). It is the sum of urinary excretion of organic acids (OAs) and potential renal acid load (PRAL). OAs is mainly determined by body surface area and it can be estimated by using anthropometric measurements (OAs (meq/d) = body surface area of the individual x 41 / 1.73) [9].

PRAL is the dietary acid load. It consists of the ratio in food of components forming either an acid or an alkali during metabolism. This is an indicator of the acid-forming ability of food products, which allows to consider not only the chemical composition of food products, but also the bioavailability of macro- and microelements, and other nutrition-independent metabolic processes in the body. The greater its positive value, the higher the acidifying effect of the product, and the greater its negative value, the higher its alkalizing effect. When food is dominated by acid-forming components, the acid load is positive. If there are more alkali-forming components in the food (organic salts of potassium and magnesium), then the acid load is a negative value.

To calculate PRAL, the average net absorption of the relevant nutrients must be considered, including protein, the degree of dissociation of phosphate at pH 7.4, and the ionic valence of magnesium and calcium.

Based on these factors determining PRAL (after taking into account the appropriate atomic weights), nutrient-specific conversion factors are obtained that allow to calculate PRAL directly from diets: PRAL (meq/d) = 0.49 x protein (g/d) + 0.037 x phosphorus (mg/d) – 0.021 x potassium (mg/d) – 0.026 x magnesium (mg/d) – 0.013 x calcium (mg/d).

To estimate total urinary NAE, it is necessary to add OAs and PRAL (NAEs = PRAL + OAs) [9].

It is important to understand that if OAs for a healthy person is a relatively stable value, then PRAL is an indicator that varies greatly depending on the menu and can be adjusted by the person himself. This is extremely important for some groups of people, for example, patients with urolithiasis, because with the help of just adjusting your diet, you can prevent the recurrence of urolithiasis. For ease of calculation, an extensive PRAL table of various products was formed (Table 1).

It is important to consider that the figures given in the table are approximate, since many factors affect the acidic properties of the product. The composition of plant food depends on the chemical composition of the soil on which it was grown, as well as belonging to one of the many varieties.

Table 1

Acid load parameters [5]

Product	PRAL (mEq/100g)	Product	PRAL (mEq/100g)	Product	PRAL (mEq/100g)
Vegetables		*Cereals and flour products*		*Meat products*	
Pumpkin	-5,6	Boiled white rice	1,7	Milk sausage	6,7
Beet	-5,4	Whole buckwheat	3,7	Pork sausage	7,0
Carrot	-4,9	Whole corn	3,8	Smoked pork sausage	7,7
Zucchini	-4,6	White rice	4,6	Lean beef	7,8
Potato	-4,0	Coarse rye flour	5,9	Lean pork	7,9
Cauliflower	-4,0	Oat flakes	10,7	Lean chicken	8,7
Red radish	-3,7	Oat	13,3	Lean turkey	9,9
Aubergine	-3,4	*Pasta*		*Seafood*	
Tomato	-3,1	Macaroni	6,1	Pike, walleye	6,8
White cabbage	-2,8	Noodles	6,4	Atlantic herring	9,1
Cucumber	-2,4	White flour spaghetti	6,5	Shrimps	10,5
Garlic	-1,7	*Bakery products*		*Eggs and dairy products*	
Onion	-1,5	Wheat bread	3,7		
Ordinary mushrooms	-1,4	Rye bread	4,1	Fat cottage cheese	0,0
Sweet pepper	-1,4	Rusks	5,9	Whole milk	1,1
Fruits and berries		*Sweets*		Whole milk yogurt	1,5
Avocado	-8,2	Honey	-0,3	Chicken egg, whole	8,2
Banana	-5,5	White sugar	0,0	Hard cheese	19,2
Apricot	-4,8	Bitter chocolate	0,4	Cheddar cheese	26,4
Melon	-4,5	Milk ice cream	0,6	*Oils*	
Kiwi	-4,1	Milk chocolate	2,4	Margarine	-0,6
Grape	-3,9	*Beverages*		Olive oil	0,0
Pear	-2,9	Carrot juice	-4,8	Sunflower oil	0,0
Orange	-2,7	Orange juice	-3,7	Butter	0,6
Pineapple	-2,7	Red wine	-2,2	*Nuts*	
Lemon	-2,6	Coffee	-2,3	Hazelnut	-2,8
Plum	-2,6	Mineralized water	-1,8	Walnut	6,8
Peach	-2,4	Indian tea	-0,3	Pistachios	8,5
Apple	-2,2	Green tea	-0,3	*Herbs and seasonings*	
Watermelon	-1,9	Beer	0	Parsley, greens	-12,0
		Vodka	0,1	Cider vinegar	-2,3
		Coca Cola	0,4	Mayonnaise classic	0,6

The properties of products of animal origin will also depend on the environment, the nature of food, health and many vital factors of the animal. Therefore, these tables do not allow for accurate calculation, but they are sufficient for daily monitoring of nutrition.

Effect of medications on urine pH. The pH level of the medium affects the rate of dissolution of most drugs. Many drugs have the ability to change the acidity of urine, so they can affect the rate of excretion of other medicinal substances. Some sulfonamides are acetylated in the body, and their acetyl derivatives can cause crystalluria with kidney damage due to poor solubility in an acidic medium. Therefore, the use of drugs that increase the acidity of urine is not recommended [10].

Antibiotics, uroseptics, and phytopreparations are the most common groups of drugs in the treatment of patients with a urological profile.

Italian and American researchers carried out a study to identify the connection between the use of antibacterial drugs and the development of urolithiasis [11].

The results have shown that women, who used antibiotics for a total of 2 months or more in the first (40-49 years) and the second age groups (40-59 years), have a higher risk of symptomatic urinary stone disease compared to the patients who did not use antibiotics in this same age group.

Urine composition was generally similar across the groups of women treated with antibiotics, with the exception of slightly lower urine pH and urinary citrate levels in patients treated with antibiotics for 2 or more months [11].

Both the effect of antibiotics on the acidity of urine, and the effect of acidity on the pharmacological action of drugs are important. It has been established that there are many factors that affect the effectiveness of antibiotics in urinary tract infections (UTIs), and pH is one such factor. Due to the fact that the pH of human urine varies over a very wide range – from acidic (pH 4.5) to alkaline (pH 8), and this factor is quite easy to manipulate, this can be a significant advantage for a better understanding of the role of pH in the efficacy of antibiotics in UTIs.

Representatives of the Department of Surgery, Department of Urology of China and Canada in 2014 carried out a study, the purpose of which was to determine the effect of pH on the activity of clinically significant antibiotics against major bacterial uropathogens [11].

An *in vitro* study has studied the activity of 24 commonly used antimicrobials against bacterial strains belonging to 6 major uropathogens (*Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterococcus faecalis*, *Staphylococcus saprophyticus* and *Staphylococcus epidermidis*) at various pH values (from 5 up to 8).

To assess the activity of antibiotics, the standard disk diffusion method and the method of serial microdilutions were used. As it turned out, for 18 of the 24 studied antibiotics, the pH value played a significant role in the overall inhibitory activity of the drug. Although most of the tested drugs have shown similar activity against most or almost all pathogens, several antibiotics had pH-dependent activity against certain pathogens.

Fluoroquinolones, cotrimoxazole, aminoglycosides and macrolides were more active in an alkaline environment, while tetracyclines, nitrofurantoin and many beta-lactams showed the highest activity in an acidic environment. The activity of sulfamethoxazole, oxacillin, amoxicillin, clavulanic acid, vancomycin, imipenem, and clindamycin was largely independent of the pH of the medium [12].

Along with antibiotic therapy, uroprotectors and diuretics based on medicinal plants are used in the treatment of inflammatory diseases of the urinary tract and urolithiasis. The advantage of herbal remedies over antibiotics is less hepatotoxicity and the absence of acquired resistance by microorganisms. [13]

Purpose of the study: establishing the relationship between changes in the pH of urine from the human diet, as well as determining the effect of medications (Nokamen) on the acidity of urine.

Materials and methods of research. We carried out a study to confirm the dependence of the actual indicators of urine acidity and the above calculations.

The study of urine pH was carried out by using a pH meter PCT-407pH manufactured in Taiwan. To achieve maximum accuracy, the instrument was calibrated every 10 measurements using standard solutions.

The study involved 53 students of the SI "Dnepropetrovsk Medical Academy of the Ministry of Health of Ukraine" (aged 20-21 years). Every day for a week, the students recorded their diet, after which every morning they gave a second portion of urine for analysis of the pH level.

The study was carried out with different groups of students throughout the year and continues to this day. All subjects can be divided into two approximately equal groups: "Students with a stable pH level" and "Students with a sharply changing pH level". First of all, the diets of those who showed stable results were analyzed, after which it became obvious that absolutely all students who consistently show a slightly acidic pH adhere to a healthy diet, with a predominance of vegetables, fruits, fish and cereals, boiled meat, as well as fried food in a small quantity. The participant, who followed a strict diet, ate low-calorie foods daily and in small quantities for three consecutive days, showed the pH of 5.56; 5.57; 5.56. For the rest of participants, acidity fluctuated within three tenths. In general, we can say that slightly acidic urine is formed with such a diet, when each meal in total gives an indicator of acid load in the range from +15.0 mEq to +28.0 mEq. The diets of the participants with neutral urine pH cannot be considered as unhealthy. Often their diets were even balanced, but there was one thing in common: no meat. The students, who neglect meat products, but at the same time consume enough cereals, fish and nuts, excreted neutral urine. The acid load of one meal ranged from +7.0 mEq to +10.0 mEq in these participants. It can be calculated that a difference of 10 mEq in acid load corresponds approximately to a difference in acidity of 0.6. (Fig. 1).

In general, we can say that the dependence of urine acidity on food consumed is quite clearly traced in people with a stable urine pH.

Acidic, slightly alkaline and alkaline environments were not encountered in these participants, even in cases where they once neglected proper nutrition and ate fast food, fatty and high-calorie foods. This suggests that the acidity of urine is a fairly stable indicator, which is difficult to change with one or two meals.

The rations of students, who showed sharp drops in urine acidity in the range from acidic 4.7 to slightly alkaline 7.8, have been studied. In this group, the correlation of acid load and urine pH was less obvious because when acidifying foods were consumed for several days, the acidity level of urine was more than 7.4, and, conversely, when a sharply acidic diet was abandoned, the acidity level of urine became slightly acidic 5.3–5.5. But with a detailed study of the diet, it was possible to reveal that all participants with sharp changes in pH have the wrong, unbalanced diet. All students who eat a lot of fast food (including sushi), and those who prefer fatty and fried home cooking, had daily acidity spikes. It should be noted that the participants who do not consume "harmful" foods at all, but at the same time eat irregularly, without a certain portion, also have an unstable level of acidity. People who drink only coffee in the morning, have "snacks" at lunch and have a hearty dinner in the evening, as a rule, show an acidic pH of 4.7-5, and those who generally severely restrict themselves in food and have several cups of coffee, a sandwich and fruits a day, show a slightly alkaline pH of 7.8-8.2.

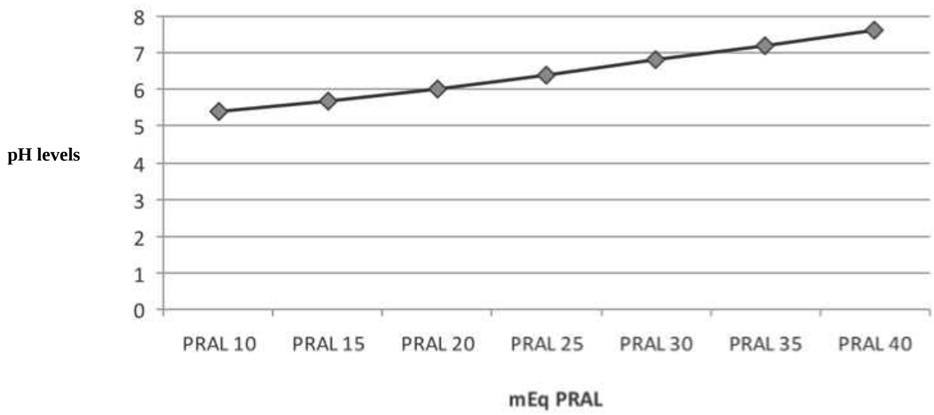

Fig. 1. Dependence of pH on the dietary acid load

The participants in the second group experienced sharp pH spikes by several units at least once every 3 days. The following important observation has been made: all the participants in the second group, unlike the first one, did not maintain the proper level of water balance. The people on the balanced diet consumed at least 1.5 liters of fluid daily (most of which was plain water), and most of the participants in the second group consumed a few cups of coffee or tea with little plain water.

Some participants were asked to adjust their diet, normalize portion sizes and meal times, and refuse fast food, fried and fatty foods. The result was not immediately observed, but within three days the level of urine acidity began to stabilize and moved into the range from slightly acidic 5.5 to neutral 7.1 (Fig. 2). This confirms the statement that the urinary system responds to an increase in acid metabolites within a few days.

Separately, we would like to note the effect of sweets and alcoholic beverages on the acidity of urine. The fact that some participants ate candy and sugary drinks daily did not affect their results in comparison with people who did not abuse sugar. Several participants drank 0.5 to 1.0 liters of beer almost daily, but they fell into the group of people with a stable neutral pH, apparently the principle of drinking enough liquids worked.

The effect of the phytopreparation Nokamen on changes in the pH level of urine has been studied (Fig. 3). The study involved 13 people with initially high acidity of urine. Each subject took Nokamen 2 tablets twice a day for 6 months. As a result of this therapy, during the first month, the pH level of the patients stabilized and was close to the average normal values (Table 2).

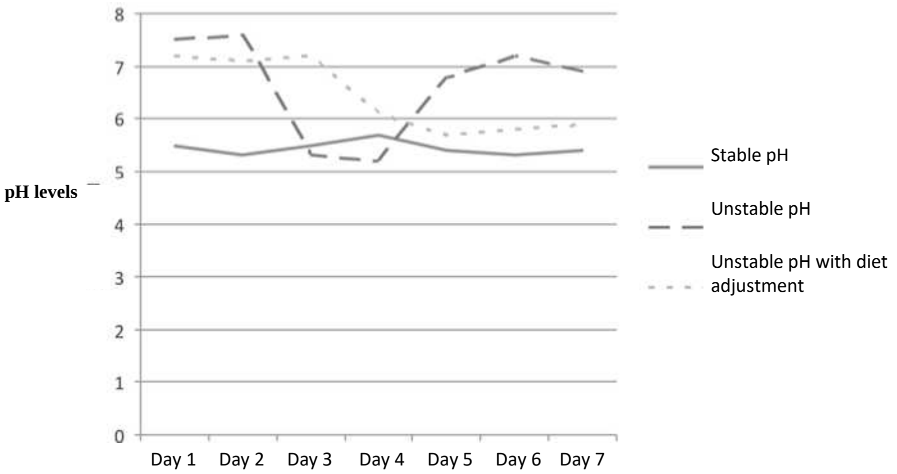

Fig. 2. Types of pH level progression

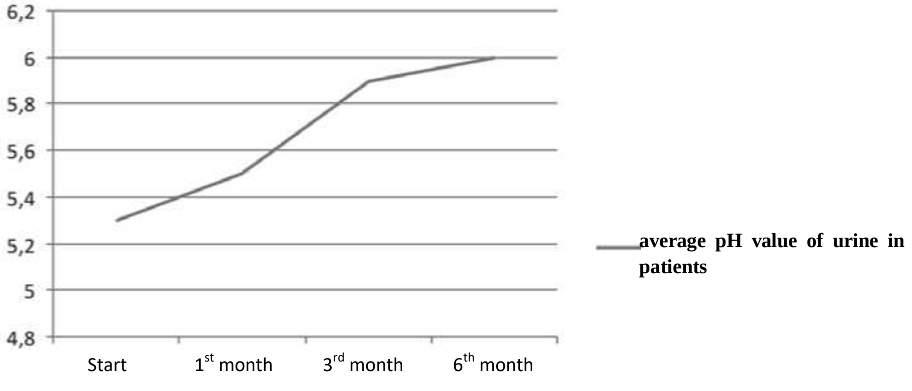

Fig. 3. Change in the acidity of urine during the reception of Nokamen

Table 2

Urine pH values at the stages of Nokamen therapy

No.	Urine pH during the first month	Urine pH after 3 months	Urine pH after 6 months
1	5,6	5,8	6,0
2	4,8	5,8	5,7
3	5,5	5,7	5,8
4	5,0	5,3	5,4
5	6,0	6,1	6,0
6	6,2	6,6	6,5
7	6,0	6,0	6,1
8	5,9	6,2	6,1
9	5,7	6,1	6,0
10	5,8	5,9	6,1
11	5,6	5,8	6,0
12	5,9	6,0	5,9
13	5,1	5,8	5,7

Conclusions

1. The acidity of human urine depends mainly on the diet. A characteristic, such as PRAL, is reliable and the acid load of 10 mEq gives a change in urine acidity of about 0.6.

2. It has been established that in order to maintain the urine pH in the natural slightly acidic range, it is necessary to regulate not only the diet, but also the diet timeliness and fragmentation.

3. The urinary system reacts to changes in the general acidity of the body within a few days, but not instantly.

4. An important role in stabilizing the level of acidity of urine is the maintenance of water balance in the body.

5. Medications can affect the acidity of urine.

6. Nokamen helps to maintain the normal pH level.

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