ANALELE UNIVERSITĂȚII "DUNĂREA DE JOS" GALAȚI
MEDICINĂ
FASCICULA XVII, no 2, 2011

REVIEW ARTICLE

THE KIDNEY - ESENTIAL ROLE IN MAINTAING THE ACID-BASE BALANCE OF THE HUMAN BODY

Laura Carmen Budala[1], Alexandru Ciocalteu[2]

[1]Faculty of Medicine, University "Dunarea de Jos" of Galati, Romania
[2]University of Medicine and Pharmacy "Carol Davila" of Bucharest, Romania

la.ro10@yahoo.com

ABSTRACT

The urinary system is referred as having one of the most complex and wonderful architectonic structures in all organic system.Homeostasis is maintained constant due to the functional suppleness of kidney.This is a complex process that requires multiple and complex enzymatic and physicochemical mechanisms.These mechanisms take place in the renal interstice,the glomerule or the proximal or distal tubules.The kidney"s ability is to maintain a perfect balance between the intake,synthesis and output of stabile acids.In the proximal tubule is happening the resorption of 85% of bicarbonate in adults and the resorption of 65% of bicarbonate in children,from the total quantity of reabsorbed bicarbonate.In the distal tubule,the rest of 15-35% of the remaining bicarbonate found in the primitive urine is reabsorbed. In the urinifer tube the urine has the pH value of 6.2 due to the fact that there are still free ions of bicarbonate.This is where H^+ ions are eliminated according to a ionic gradient or reference scale.In chronic kidney failure it is absolutely necessary that we intervene exogenous to try to maintain the body homeostasis.Without these reactions the patients progress will irremediately lead to exitus.

KEYWORDS: *homeostasis, the kidney, the acid-base balance, the chronic kidney failure.*

The urinary system is clasically considered alongside the digestive system, the main "cleamser" of catabolic residues that are no longer needed in the human body. It is referred to as having one of the most compex and wonderful architectonic structures in all organic system. [1]The kidney, central piece of the renal system, has so many funcions that the mere listing of the best known of them, is amaizing when introduced in the study of human body physiology.

So:

A) The kidney has a leading part in preserving the homeostatic equilibrium of the body, by eliminating the final products of metabolism;

-isovolemic: maintaining liquid volume constant;

-isotonic: maintaining osmotic pressure constant;

-isoionic: maintaining ions concentration;

-isohidric: maintaining hydrogen concentration constant thus adjusting the acid-base balance.

B) The kidney also has an endocrine function by:

- releasing into the blood stream substances that act as hormones : rennin, prostaglandins, eritropoietin, D3 active vitamin ;
- reacting as “receiving end” or “effector” to hormones secreted by other organs into the blood stream .

C) The kidney has antitoxic and metabolic function [2-5]

Homeostasis is maintained constant due to its functional suppleness.

In the evolutionary process of all living things, homeostasis was the most difficult to achieve : it means realizing a perfect balance (homeo- similar, alike; stasis- maintaining, preserving) that is not disturbed by the outside environment. Only like this, in fixed, given conditions, can all of the bodys’ cells, organs, systems function at their best, or hightest parameters. To achieve this goal the human body burns or uses half of the energy resulted from basal metabolism.

Every second the human body goes through multiple changes that tend to break this frail balance. There are multiple changes in progress in every second, an ongoing transformation, continuous labor. The liaison between different organs, that keeps everything connected is of course the circulation of the blood : this is where most of the residual accumulation happen (CO2, acids, catabolism residues from all the chemical reactions that happen in the cells). Even thought it experiences so many changes, the blood is also extremely constant and it’s parameters, in other words, homeostasis, is maintained by any means. This is the only way the cells are kept intact, as it is a well known thing the fact that even a few minutes of chemical imbalance would permanently damage them (ex: the neuron) thus the importance of the urinary system that is permanently eliminating excess substances, toxic compounds, even substances that have accidentally got into the body, its balances hidric, ionic, electrolytic and acid-base values. [1]

As a result, the homeostasis is obtained by the constant filtering and eliminating the urine. This is a complex process that requires multiple and complex enzymatic and physicochemical mechanisms. These mechanisms take place in the renal interstice, the glomerule or the proximal or distal tubules.

The ultrafiltration of the blood circulation tahes place at the surface of the glomerular capillaries. Then , along the proximal and distal tubules different processes take place under the hormonal output. This processes are either compulsory or selective. As a result, the renal nephrons are in interface between the bodys’ internal environment and the outer environment. At the end of all these processes, the final urine will have a chemical structure totally different from the original plasma-like composition . the substances that are no longer needed by the body are purged from the system, thus maintaining the internal balance. [1,6]

By studying the urine, we can tell both if the kidneys function properly and on the other hand we can take into account everything that happens in the body. This mobility, this physiological characteristic, this pliability of its function can result in so many different kinds of urines, all of them as a result of a continuous action of preserving homeostatic balance. [1]

The internal structure is modified by a lot of things: the effort to keep all organs and systems going properly, the daily quantity of food and liquids ingested and even physical effort. [1]

Metabolic functions that are performed by the bodys’ cells will result in predominantly acid compounds.

The bloods’ buffer systems have the task of keeping constant the extracellular and intracellular liquid matrix pH balance. The blood, component of the extracelular matrix maintains its pH balance by: -the buffer action;

-respiratory elimination of CO2;

-the kidneys ability to maintain a perfect balance between the intake, synthesis and output of stabile acids.

Stabile acids are formed by:

-the incomplete oxidation of carbohydrates and fats with the forming of organic acids;

-the oxidation of aminoacids that have in their composition sulphur, that leads to the formation of organic acids;

-the hydrolysis of esthers. [1,2,7,8]

The body will counter to the continuous production of acids, to neutralize them using sanguine buffer systems (the main role being played by bicarbonate) and also renal excreting the acid products. As a result, there must be continuous resorption of bicarbonate in the tubules, action that is accomplished in proportion of 99,99 per cent by glomerular filtration . [1]

But the kidneys role in maintaining acid-base balance is much more vast and it concerns the involvement of three key sectors:

-the proximal tubule: here is where the rosorption of 85% of bicarbonate in adults and the resorption of 65% of bicarbonate in children, from the total quantity of reabsorbed bicarbonate. The reabsorbtion of the bicarbonate ion is connected to the reabsorbtion of the sodium ion.

-the distal tubule: this is where the rest of 15-35% of the remaining bicarbonate found in the primitive urine is reabsorbed , in part due to an aldosteron dependant mechanism.

-the urinifer tube: here the urine has the pH value of 6.2 due to the fact that there are still free ions of bicarbonate. This is where H ions are eliminated according to a ionic gradient or reference scale. These H ions will be eliminated with the help of 2 buffer substances: phosphates and ammonium. [2,4,9,10]

The kidneys are fallible by a number of very different factors and situations: genetic anomalies, medicines, and toxic substances, infections, obstacles, or obstructions, circulatory or homeostasis disturbances, autoimmune diseases. [1]

Also the renal structure may suffer in the case of: changes in the renal blood flow, extended renal ischemia, where there can be noticed functional repercursions in the tubules; toxic substances or drugs can affect renal interstice when eliminated urinary; autoimmune disease can affect the renal glomerules.

In the case of chronic renal disease, the nephrons have great functional tolerance. This means that alterations of the renal functions only occur after the distruction of 60-90% of the nephrons. The remaining healthy nephrons, undertake functional adaptive modifications in order to take over the affected nephrons activity. [1,6]

Sometimes after some illness, the secondary renal lesions that occur, cab be healed, with tisular repair and complete restoration of the renal function; also some diseases can lead to glomerular sclerosis or interstitial or tisue fibrosis that ultimately lead to irreversible renal lesions.

If other factors like : male genre ; nutrition and metabolic conditions ; high arterial pressure ; types of underlying nephropathy ,are met invariable deterioration is inevitable. [1,2,11]

In the unfortunate case of all the nephrons being destroyed the patient finds itself in chronic kidney failure and is eligible for the substitution of renal function such as dialisys or kidney transplant.

Even ithe early stages of chronic kidney failure (RFG 30 ml\min) metabolic acidosis occurs. There is a decrease in the synthesis of ammonium in the proximal tubules. The decrease in the ammonium synthesis will also decrease the formation of NH4 and by doing so the excretion of H ions. As a result, the reabsobtion and renewing of bicarbonate decreases. Metabolic acidosis is initially balanced by hyperventilating. At this stage, the plasma bicarbonate is low, the blood pH is normal and Pco2 is low (metabolic acidosis + respiratory alkalosis) . The compensatory mechanism of balancing through hyperventilating can be exceeded; metabolic and respiratory acidosis will occur. Plasma bicarbonate and blood pH will drop and pCO2 will rise. [7,12-15]

All of these reactions will lead to the break of that delicate inner balance. The body will no longer be able to maintain homeostasis. As a result, in chronic kidney failure it is absolutely necessary that we intervene exogenous to try to maintain the body homeostasis. [12,16]Without these reactions the patients progress will irremediately lead to exitus.

References

1. Covic A.,Covic M.,Segall L.,Gusbeth-Tatomir P.: Manual de Nefrologie,Ed.Polirom, 2007: cap.1 Anatomia functionala a rinichilor 16,23-25; cap15 Boala cronica de rinichi 279-330; cap.19 Echilibrul acido-bazic 381-399.

2. Rădulescu D., David C., Ciocâlteu A., Mocanu B., Costache D.M: cap.2 Fiziologie si fiziopatologie renala in Tratat de Nefrologie – Al.Ciocalteu,Ed.National: 17-161,2006; cap. 16 Insuficienta renala cronica in Tratat de Nefrologie - Al. Ciocâlteu, Ed. Național: 593-642

3. Badescu M.,Rosca M.,Bohotin C. : Fiziopatologie Generala,Editia II,Ed.Cantes,2000: cap.15 Fiziopatologia echilibrului acido-bazic 484-499.

4. Bunu C.: Fiziologia aparatului urinar :http://www.justmed.eu/files/fiziologie/Ren-Curs;pdf

5. Sabau I. : Acidozele tubulare renale ,Revista Peditru.ro,An IV, nr.9,III,2008

6. DuBose Th.D : Nephrology in the new millennium; W.B. Saunders, 2000

7. Rose B.D., Post Th.W.: Clinical Physiology of acid-base and electrolyte disorders, Fifth Edition, McGraw-Hill,Medical Publishing Division ,2001

8. Tiplic T. : Anatomia şi fiziologia omului III; Ed. Aktis – Bucureşti, 1999

9. Schrier R.W. : Renal and electrolyte disorders; Lippincott Williams & Wilkins, 2010

10. Kerry Brandis: Acid base physiology : Renal regulation of acid-base balance; American Thoracic Society;2008

11. Pradeep A., Verrelli M.: Chronic renal failure, article WebMDProfessional ,2009,(238-798)

12. Krause R.S. : Renal failure,chronic and dialysis complication, article WebMDProfessional ,2009 (777-957)

13. Levey A.S.et al. : Chronic kidney disease: common, harmful and treatble - World Kidney Day 2007. Pediatr. Nephrol. 2007; 22: 235-237

14. Brent Alper Jr. A.,Shenava R.,Young B.A.: Uremia , article WebMDProfessional ,2009,(245296)

15. Hipp A.,Sinert R. : Metabolic acidosis, article WebMDProfessional , 2008, (768268)

16. Yaseen S., Thomas P.C.: Metabolic alkalosis , article WebMDProfessional ,2009, (243160)