ISSN 0974-3618 (Print) 0974-360X (Online) www.rjptonline.org

REVIEW ARTICLE

The use of Antihypertensive Therapy in Hemodialysis and the Urinary System as a Conceptual Model

Chergizova B[1], Ishigov I.[2], Ryspayeva G.[1]*, Ashimbekova B.A.[3], Kharissova N.[1], Mkhitaryan X.[1] , Smirnova L.[3]

[1]Karaganda Medical University" NCJSC, Karaganda, Kazakhstan.
[2]Akhmet Yassawi International Kazakh-Turkish University, Turkistan, Kazakhstan.
[3]Kostroma State University, Russia.
*Corresponding Author E-mail: **anzorinabiba@mail.ru**

ABSTRACT:

The use of techniques and methods in teaching medical students that combine the principles of problem-solving and modeling in educational practice helps to develop their ability to independently acquire new knowledge and collect the necessary information. Many problems that are unsolvable when setting up real experiments turn out to be easily eliminated in computer modeling, increasing the visibility and scientific and theoretical level of presentation of the material. The use of virtual and experimental models provides an opportunity for real representation, as well as visual transformations of objects ranging from the cellular to the system level. The knowledge, skills, and new experience acquired in this process can play an essential role in the development and formation of a person both as a professional and as a person in general. The relevance of the modeling method in preparing presentations for independent work of students plays an important role in the accumulation of material on disciplines, including integrated ones, effectively developing clinical thinking, skills and abilities to work in a team, acquiring skills in modern medical technologies. The purpose of the publication was to use angiohypertensive therapy in hemodialysis as a clinical model and the effectiveness of using current modeling methods in the process of studying topics on the module "Urinary system" in the course of normal physiology for students of a medical university. The modeling method as a competence-based approach and its implementation in the educational process along with innovative teaching technologies will expand the practical skills and professionalism of junior students. In the future, this will increase their creative potential in senior years when studying the discipline "Pathological Physiology".

KEYWORDS: Hemodialysis, Angiotensin therapy, Renal regulation, Competencies, Hypertension, Modeling method, Innovative technologies, Urinary system, Integration.

Received on 01.10.2024 Revised on 10.02.2025
Accepted on 11.04.2025 Published on 01.07.2025
Available online from July 05, 2025
Research J. Pharmacy and Technology. 2025;18(7):3366-3373.
DOI: 10.52711/0974-360X.2025.00487

INTRODUCTION:

The development of intradialysis hypertension is accompanied by an increased risk of hospitalization and mortality in patients with renal insufficiency and at the present stage requires a thorough study of the possibilities of controlling the physiological mechanisms of action. Currently, there are practically no studies on the feasibility of effective treatment of intradialysis hypertension, many researchers note[1,2,3,4,5,6]. The pathophysiology of arterial hypertension on hemodialysis includes a number of mechanisms that mark frequent increases in blood pressure on dialysis. Studies using bioimpedance spectrometry show that approximately 50% of patients on hemodialysis experience overload phenomena and the occurrence of hyperhydration syndrome ("overloud"). This course determines an unfavorable prognosis in the form of an increase in the risk of mortality by 26%, as one of the reasons for such a prognosis is high blood pressure[7,8]. To date, what blood pressure should be on dialysis has not yet been determined. According to the DOPPS study, the lowest risk of mortality was observed at the level of SAD in the predialysis period from 130 to 159 mmHg. and according to the CRIC study, the lowest risk of cardiovascular mortality is at the level of SAD in the predialysis period of 138-166 mmHg[9,10,11,12,13].

One of the important factors leading to an increase in blood pressure is the overload of the patient's body with sodium for natural reasons and due to a decrease or absence of sodium clearance by the urinary system. Studies by Kauric-Klein Z.[14] have shown that higher dietary sodium intake is independently associated with higher mortality in patients receiving hemodialysis treatment. The question remains open about which period it is necessary to measure blood pressure in order to minimize the risk of mortality — predialysis, intradialysis, postdialysis or interdialysis[15].

Interactive modeling methods are used in medical universities to interpret and study the physiological and pathophysiological mechanisms of this pathology. At the Department of Physiology of the non-profit joint-stock company Karaganda Medical University, for conducting classes for 1–2-year students of the Faculty of General Medicine, studying under the credit integrated system, by the teaching staff of the module "Exchange with the environment. Metabolism and energy" in the discipline "Urinary system", various interactive teaching methods are developed and used in the classroom, increasing many professional competencies of students. Along with a variety of interactive methods (team learning method – TBL, problem – RBL), computer technologies and experimental modeling of physiological processes are used.

The use of innovative forms of teaching physiology is one of the urgent problems of modern teaching methods and depends on some factors. 1) The credit-modular system of the educational process proceeds very intensively and in a short time. 2) There is a problem of information overload, as the topics are too broad and the hours allocated to them are insufficient. This causes poor perception of complex and voluminous information. 3) Students have a limited vocabulary and therefore have poor command of the communicative function of the language, which makes it difficult to form thoughts and convey them orally[16,17,18]. In this regard, these hindering factors are supposed to be solved using modeling technology and visual representation of systemic physiological processes in the classroom: to maintain students' interest in the material being studied and to activate their activities throughout the lesson; to increase motivation to study the subject; to develop communication skills and form a collective skill necessary for a future doctor[19,20].

THE AIM OF THE STUDY:

was to analyze the therapeutic and pharmacological effects of angiotensic drugs in hemodialysis and to show the application of the modeling method in the process of studying topics in the module "Exchange with the environment. Metabolism and energy" in the discipline "Urinary system" and the effectiveness of using relevant teaching methods in the course of normal physiology for undergraduate students.

To achieve this goal, the following tasks were set: 1) to study the pharmacological diagnosis of various drugs and treatment regimens for hemodialysis; 2) to determine the pedagogical foundations of active teaching methods, in particular, the method of modeling kidney physiology and the hemodialysis process; 3) to develop practical exercises using an interactive modeling method and to test it at the subject Olympiad in "Physiology".

MATERIALS AND METHODS:

To study the effect of various pharmacological agents in programmed hemodialysis, to develop and demonstrate to students the importance of the basic physiological functions of the kidneys by using the modeling principle[21,22,23]. The main functions of the urinary system are the formation, accumulation and excretion of urine. Metabolic products, excess fluid, and harmful substances are excreted in the urine. In addition, thanks to the work of the kidneys, the body maintains a normal level of blood pressure, an optimal balance of fluids and electrolytes such as sodium, potassium and chlorine, regulates the production of iron-containing blood protein hemoglobin, a number of hormones, and ensures normal bone mineral density.

The kidneys perform the following functions:

1. Excretory and secretory function. The kidneys remove excess water, inorganic and organic substances, nitrogen metabolism products and foreign substances from the body: urea, uric acid, creatinine, ammonia, medicines.
2. Regulation of the water balance and, accordingly, the volume of blood, intracellular and intracellular fluid (volumoregulation) by changing the volume of water excreted in urine.
3. Regulation of the stability of osmotic pressure of liquids in the internal environment by changing the amount of osmotically active substances released: salts, urea, glucose (osmoregulation).
4. Regulation of the ionic composition of the fluids of the internal environment and the ion balance of the body by selectively changing the excretion of ions in

the urine (ion regulation).

5. Regulation of the acid-base stage by the release of hydrogen ions, non-volatile acids and bases.
6. Formation and release into the blood of physiologically active substances: renin, erythropoietin, the active form of vitamin D, prostaglandins, bradykinins, urokinases (endocrine function).
7. Regulation of blood pressure levels due to the internal secretion of renin, depressive substances, the release of sodium and water, changes in the volume of circulating blood.
8. Regulation of erythropoiesis through the internal secretion of the humoral regulator erythropoietin (erythron).
9. Formation of humoral regulators of blood coagulation and fibrinolysis – urokinase, thromboplastin, thromboxane, as well as regulation of hemostasis by participating in the physiological anticoagulant metabolism of heparin.
10. Participation in the metabolism of proteins, lipids and carbohydrates (metabolic function).
11. Protective function: removal of foreign, often toxic substances from the internal environment of the body.

Urination is carried out by three successive processes: 1) glomerular filtration (ultrafiltration) of water and low molecular weight components with the formation of primary urine from blood plasma into the capsule of the renal glomerulus; 2) tubular reabsorption - the process of reabsorption of filtered substances and water from the initial urine into the blood; 3) tubular secretion - the process of transition of ions and tubules of organic matter from the blood into the lumen.

THE RESULTS OF THE STUDY.

A clinical study of dialysis allows us to demonstrate the physiological mechanism of action of the hemodialysis process, its clinical features and course. According to Tokareva A.S. and co-authors[20,21,22], the presence of intradialysis hypertension (IDH) is an independent risk factor for general and cardiovascular mortality in dialysis patients. As one of the pathophysiological mechanisms of increasing intradialysis blood pressure, a decrease in the concentration of highly dialyzed antihypertensive drugs during a hemodialysis session is considered.

The use of drug therapy with antihypertensive drugs showed the predominance of highly dialyzable pharmacological agents in the treatment of patients on hemodialysis. This therapy with drugs with high dialysis clearance was associated with an increase in the incidence of interdialysis hypertension to 95% ($p<0,0001$). At the same time, hypertension occurred in 60% of dialysis patients and was associated with the use of beta-blockers ($p<0,015$), moxonidine ($p<0,001$) and highly dialyzable drugs ($p<0,0001$). In the multivariate model, the use of beta-blockers lost its significance, giving way to highly dialyzable antihypertensive drugs and moxonidine[23,24].

Hemodialysis is a procedure in which a dialysis machine and a special filter called an artificial kidney or dialysis are used to purify the blood. In order for blood to enter the dialyzer, the doctor must make access or entry into the blood vessels. This is done with a small operation, usually on the arm. In the form of:

Arteriovenous fistula (AV fistula): The surgeon connects an artery and a vein in the arm

Arteriovenous graft (AV-transplant): If the artery and vein are too short to connect, the surgeon will use a graft (soft, hollow tube) to connect the artery and vein.

If dialysis needs to be performed quickly, your doctor may place a catheter (thin tube) into a vein in your neck, chest, or leg for temporary access.

During hemodialysis, the dialysis machine: Removes blood from the needle in the hand.

Circulates blood through a dialysis filter, which moves waste into the dialysis solution. This cleansing liquid contains water, salt and other additives. Returns filtered blood to your body through another needle in your hand. Monitors blood pressure to regulate how fast blood flows into and out of the body.

To demonstrate the clinical significance of the dialysis procedure, the students also independently made a mock-up (Figure 1).

Figure 1. Layout of the hemodialysis system

The dialyzer, or filter, consists of two parts: one for blood and one for a flushing fluid called dialysate. A thin membrane separates these two parts. Blood cells, protein and other important things remain in the blood because they are too large to pass through the membrane. Smaller waste products in the blood, such as urea, creatinine, potassium and additional fluid, pass through the membrane and are washed away.

During dialysis, you will have to limit: *odium in food and beverages. foods with a high phosphorus content. The amount of liquid you drink, including the liquid that can be found in foods. Fluid accumulates in the body between hemodialysis procedures[25-26]. You may also need to: add protein to your diet, because hemodialysis removes protein, Choose foods with the right amount of potassium, Take vitamins made for people with kidney failure, Find healthy ways to add calories to your diet due to a weak appetite.

Students, under the guidance of a teacher of the department, independently made a mock-up of a software hemodialysis system, consisting of 3 stages – a prototype arm, then we form arteries and veins from plasticine passing through the forearms (M, N-shaped), where we will insert the future tube (fistula) and the support of the layout. Necessary materials: cardboard, foam plastic, colored and decorative paper, box, scissors, glue gun, battery, switch/start, a set of medical droppers and tubes, waste jars, DC water pump, paint, stationery knife, plasticine. The next stage consists of a vessel as a future dializer. Thus, our dializer is ready. It is necessary to add small tubes to the vessels, connect them with a bottle (dializer) and fill one with yellow and the other with blue (clean and dirty dialyzer liquid, respectively). Next, all the ends of the dialyzer tube must be placed in a plastic tub, where one end will be attached to the pump, connected by a battery to the start. Fill the tub with red paint. Turn on the pump and start checking the layout. As a result, blood is circularly purified on a dialyzer model, where "dirty" blood is taken from one end, and "clean" blood is returned from the other. There are many indications for dialysis, but most often dialysis is prescribed due to the inability of the kidneys to properly filter waste products from the blood (renal failure). Kidney function may deteriorate rapidly (so-called acute kidney injury or "acute renal failure", or the kidneys may lose their ability to filter waste products slowly (so-called "chronic kidney disease or chronic renal failure").

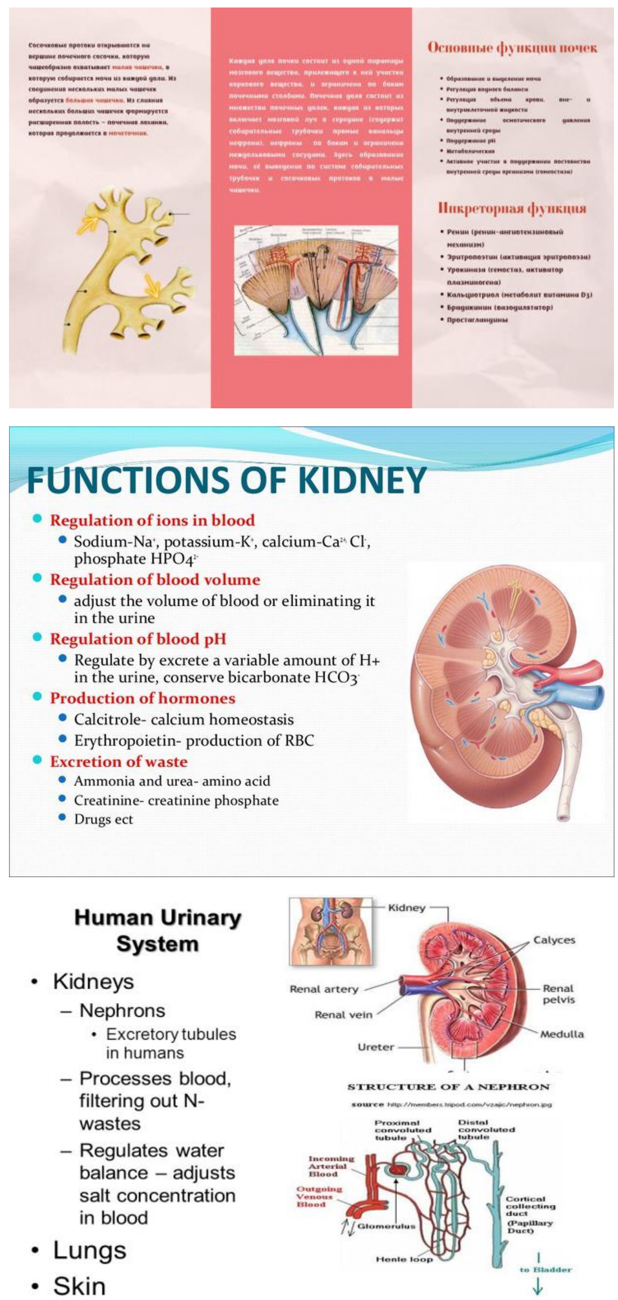
In people with renal insufficiency, many doctors recommend dialysis if blood tests show that the kidneys are no longer able to efficiently filter out waste products, and the accumulation of metabolic products causes problems[27,28,29,30]. In case of acute kidney damage, doctors continue dialysis until the results of a blood test show that kidney function has recovered. In patients with chronic kidney disease, dialysis can be performed as a long-term therapy or as a temporary measure until the patient receives a kidney transplant. Dialysis treatment can be performed for a short time, as an emergency or intensive therapy, to remove fluids, drugs or poisons from the body[31]. One of the main concomitant diseases in dialysis patients is arterial hypertension. The study[32] showed that the prevalence of hypertension in hemodialysis patients was 72% (mean blood pressure before dialysis session ≥114mmHg). At the same time, the majority of patients (80%) had an increase in both systolic and diastolic blood pressure. Isolated systolic hypertension was present in only 20% of patients. The pathogenesis of arterial hypertension in dialysis patients is quite complex and includes three functional states: 1) increased cardiac output, 2) increased stiffness of large arteries, and 3) intense wave reflection (arteriole spasm). After a hemodialysis procedure, ultrafiltration and changes in plasma volume can often lead to episodes of hypotension[33].

The effect of drug correction of blood pressure on the survival of patients on dialysis has not been definitively studied at present. There are few single studies devoted to this issue by Hif J., Heiro M., Petersons A[34]. Arterial hypertension is an important risk factor for the development and progression of not only cardiovascular diseases, but also chronic kidney disease (CKD). At the same time, CKD is an important independent risk factor for the development and progression of cardiovascular diseases. Various approaches can be used in the selection of drug doses for patients in need of renal replacement therapy. Each class of antihypertensive agents (beta blockers, calcium channel blockers, centrally acting drugs, alpha blockers, vasodilators), with the exception of angiotensin converting enzyme (ACE) inhibitors, reduced mortality in unregulated models. At the same time, the most pronounced effect was observed when taking beta blockers (risk ratio 0.72. 95%; confidence interval (CI) from 0.66 to 0.79 was provided only by beta blockers. Thus, dose adjustment of drugs for the pharmacotherapy of arterial hypertension in patients on hemodialysis should be carried out individually, taking into account the characteristics of the prescribed drug and the characteristics of the patient[35]. Also, all patients showed a significant decrease in the concentration of nitrogenous plasma metabolites – creatinine and urea, characteristic of hemodialysis, which in the second group often turned out to be even lower than the physiological norm. Changes in hemodynamic parameters were also significant. 4-6 hours after its onset, systolic blood pressure was restored to a physiological level (on average from 62±13 to 86±5 mmHg) against the background of normal heart rate and an increase in heart rate from 1037±110 to 1430±86 din.sec.cm-5.m$^{-2)}$[36,37,38].Normalization of hemodynamics also contributed to the restoration of filtration pressure in the renal glomeruli, which led to an increase in diuresis from 440±320 to 1600±560ml per day. The glomerular filtration rate after BP increased from 22.5±9.2ml/min to 90.9±22.1ml/min. Thus, albumin dialysis had a direct nephroprotective effect, apparently associated with the effect of hemodynamic stabilization.

The data obtained indicate a direct nephroprotective effect of albumin dialysis in acute hepatic and renal insufficiency. Hemodiafiltration, despite some positive laboratory dynamics, did not change the course of acute hepatic-renal insufficiency. In all patients, an increase in hemodynamic instability was noted, and in 9 out of 10 cases, a fatal outcome was noted after 2-3 hemodiafiltration, in connection with which this type of extracorporeal detoxification in acute hepatic and renal insufficiency can be considered ineffective. The effectiveness of albumin dialysis was significantly higher. One of the significant factors in the development of cardiovascular pathology in this category of patients is oxidative stress. This condition is defined as a violation of the balance between the excessive formation of free radicals and the implementation of antioxidant defense mechanisms. Free radicals directly damage endothelial cells, accelerate the destruction of nitrogen monoxide, shift the balance of endothelial factors towards vasoconstriction, trigger an inflammatory reaction that increases tissue damage, and contribute to the development of atherosclerosis[39,40,41].

The use of antioxidants and vitamin C restores the balance between free radical oxidation and antioxidant protection, reduces the risk of cardiovascular complications, increases the duration and improves the quality of life of patients on hemodialysis[42,43,44]. Modeling of physiological processes by means of computer graphics, mockups and experimental models is the simplest and most accessible tool for many educational departments and laboratories to demonstrate various processes and phenomena[45,46]. Many problems that are unsolvable in setting up real experiments turn out to be easily solved in computer modeling. Such layouts and models allow not only to better understand the fundamental physiological phenomena and laws, but also to get acquainted with the basic techniques of conducting and processing a natural science experiment in the educational process.

The main modeling work was divided into 4 stages. At the 1st stage, a kidney layout was performed. According to the plan, the right kidney is made whole, and the left one is partially in order to show the internal structure. At the 2nd stage, the work of the tubular system with the help of tubes was demonstrated. At the 3rd stage, the filtration process and the formation of final urine in the bladder were performed, since urine passed through the kidneys is delivered through the ureter to the bladder. At the 4th stage, a human mannequin of the torso was taken and all the obtained functional parts of the system were assembled in the form of a single whole mechanism. Kidneys, bladder, and ureter were placed inside the mannequin, a hole was made in the neck of the mannequin and a tube was attached there from above. After the middle part of the abdomen was cut out so that the kidney was clearly visible, we attached the kidney to the outer edges of the abdominal section by pulling it through the attachment. According to the anatomical location, we placed the right kidney above the left one. Thus, the layout created to describe the urinary system was presented in the form of interconnected organs and tubes forming an integrated system. As an additional material, we extract information in the form of a booklet that will be useful in connection with the educational process (Figure 2). A booklet and presentation in PDF format were created as visual modeling.



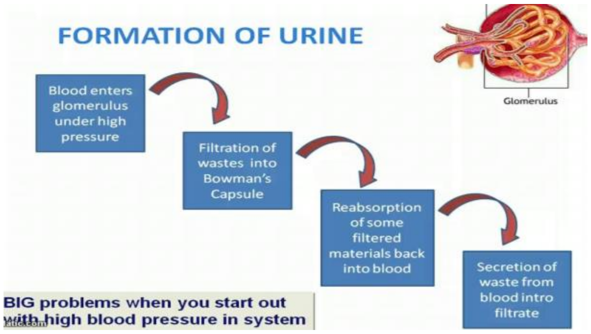


Figure 2. Booklet for the educational process

The urinary system is one of the most important systems of the human body. Its main task is to filter the blood and maintain the balance of body fluids by excreting urine from metabolic products obtained from the blood. The continuous work of the kidneys regulates the water-salt and acid-base balance in the body. During the day, about 170-180 liters of blood flows through the kidneys, and urine is produced about 1.5 liters. This is a cyclic process that occurs in the following sequence (Figure 2). Students get acquainted with the mechanisms of urinary function, shown in Figure 3.

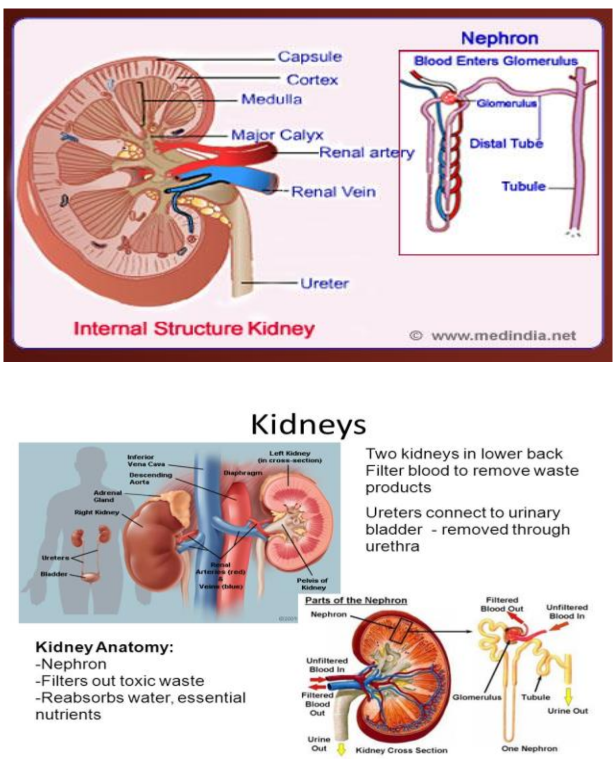


Figure 3. Scheme of the urinary process in the kidneys

Thus, modeling, as a modern innovative method, can justifiably be a teaching tool that activates the mental activity of students, makes the learning process more attractive and interesting, and forms a powerful incentive to master knowledge in the studied disciplines. Independent and creative execution of layouts allows you to create positive motivation, concentrate intellectual efforts, mobilize students' mental abilities, their imagination, attention, and memory. At the same time, it requires the search for sources and the assimilation of educational material. Modeling creates conditions for updating the entire communicative experience of students. These techniques are most applicable in self-study under the guidance of a teacher.

Modeling human physiology is an important area of research that allows us to better understand and predict the functioning of the body. It is the process of creating simplified mathematical or computer models that reflect various aspects of human physiology. Modeling of human physiology has a wide range of applications, including the development of new drugs, optimization of treatment procedures and training of medical specialists[47,48,49,50,51].

CONCLUSIONS.

Based on the results obtained and the study of numerous studies conducted, albumin dialysis is currently an effective treatment method in the modern period. This method is indicative for the elimination of both hydrophobic and hydrophilic toxic substances that accumulate in acute hepatic and hepatic-renal insufficiency. Albumin dialysis is effective, safe and easy to use and is well tolerated by patients. This method may be useful as a preparatory therapy before liver transplantation in patients with acute or chronic liver failure.

Despite the widespread use of hemodialysis, the constant improvement of equipment and consumables used for its implementation, the improvement of pharmacotherapy accompanying hemodialysis, cardiovascular pathology remains the main cause of death of patients undergoing programmatic hemodialysis treatment[52,53,54]. Dialysis patients are exposed to both traditional risk factors for cardiovascular diseases and numerous additional ones associated with uremia and dialysis itself. The relative risk of death from cardiovascular causes is 10 times higher in dialysis patients than in the general population[55]. In many clinical studies[56,57], it was shown that the overall benefit of antihypertensive therapy in terms of its effect on cardiovascular was 95% of the effects. When analyzing the subgroups, it was found that antihypertensive therapy had a positive effect to a greater extent in patients with 95% elevated blood pressure than in normotonics.

As is known, all functional systems support the homeostasis system in the body. Epidemiological studies consistently demonstrate that cardiovascular, renal and metabolic diseases often overlap and coexist in the same patients. To prevent and treat these diseases, doctors recommend monitoring blood pressure. This can be done with certain medications, as well as by changing your lifestyle. Drinking enough water and staying hydrated is another good way to stay active and prevent exacerbation of diseases. But the cardiorespiratory system, which is regulated by nervous and humoral mechanisms, plays a decisive role in this. Optimization of the cardiovascular and respiratory systems is of great importance for increasing the level of physical performance. Systematic intense muscle activity causes a complex of responses of the body, differentiated functional and structural changes, providing adaptive specificity of physical and educational loads. Physical exercise has a powerful adaptogenic effect, triggering several regulatory mechanisms in the autonomic support systems, primarily in the cardiovascular, respiratory and urinary systems[58,59,60].

Significant modernization of medical education, new approaches have been formed to motivate medical students to acquire new knowledge, specialized training programs have been developed, including in normal physiology, with an emphasis on the use of computer technologies and simulation techniques[12,13]. The increase in the effectiveness of training is due to an increase in students' motivation to study and interest in acquiring new knowledge, skills and abilities when using active teaching methods. In general, this increases the communication skills and intellectual value of students.

Over the past decade, significant modernization has taken place in medical education, innovative approaches have been formed in the training of students of medical universities[15,45], new curricula have been developed. Currently, the modern educational process is actively introducing model and experimental innovative forms and means of learning. It is impossible to imagine a modern medical university without innovative activities.

REFERENCES:

1. Batalova T.A., Grigoriev N.R., Cherbikova G.E., Gasanova S.N. Innovative methods of teaching students in the process of teaching normal and clinical physiology. Amur Medical Journal Medical Education. Komsomolsk-on-Amur. 2020; 1(29): 98-101.
2. Yavorskaya S.D., Nikolaeva M.G., Bolgova T.A., Gorbacheva T.I. Innovative methods of teaching students of a medical university. Modern Problems of Science and Education. 2016; 4. https://doi. org: science-education.ru/ru/article/view?id=24979
3. Balaev A.A. Active Teaching methods. Profizdat. M.; 1994.
4. Marin JJ, Beresford L, Lo K, Pai A, Espino-Hernandez G, Bollier M. Prescribing patterns in patients on dialysis: differences between hemodialysis and peritoneal dialysis patients and potential for prescription cancellation. Can J Dis. 2020; 7 : 2054358120912652. https://doi.org/10.1177/2054358120912652.
5. Paik JM, Kyaw M, York K, Tsakogiannis T, Kim SK, Desai RJ. Medication burden and prescribing patterns in US hemodialysis patients, 2013-2017. Am J Nephrol; 2021; 52(12): 919-928. https://doi.org/10.1159/000520028.
6. Manley HJ, Garvin CG, Dreyer DC, Reid GM, Bender WL, Neufeld TK, et al. Medication patterns in patients on outpatient hemodialysis: a comparison of USRDS data with data from a large not-for-profit dialysis organization. Nephrolith Transplant. 2004; 19(7): 1842-1862.
7. Zoccali C, Moissl U, Chazot C, Mallamaci F, Tripepi G, Arkossy O et al. Chronic fluid overload and mortality in ESRD. J Am Soc Nephrol. 2017; 28(8): 2491–2497.
8. Seong EY, Zheng Y, Winkelmayer WC, Montez-Rath ME, Chang TI. The relationship between intradialytic hypotension and hospitalized mesenteric ischemia:Case-Control Study. Clin J Am Soc Nephrol. 2018; 13(10): 1517–1525. https//doi. org:10.2215/CJN.13891217.
9. Robinson BM, Tong L, Zhang J, Wolfe RA, Goodkin DA, Greenwood RN et al. Blood pressure levels and mortality risk among hemodialysis patients in the dialysis outcomes and practice patterns study. Kidney Int. 2012; 82(5): 570–580.
10. Bansal N, McCulloch CE, Lin F, Alper A, Anderson AH, Cuevas M et al. Blood pressure and risk of cardiovascular events in patients on chronic hemodialysis: the CRIC study (Chronic Renal Insufficiency Cohort). Hypertension. 2017; 70(2): 435–443.
11. Rinku Yadav, Keshav Bhandari, Shivani Sah, Richa Singh, poonam kumari Yadav. Quality of life related to the health of patients with chronic kidney disease undergoing hemodialysis at Birgunj National Medical College and Teaching Hospital, Province 2, Nepal. A and V Pub International Journal of Nursing and Medical Research. 2024; 3(1): 6-12. https:// doi: 10.52711/ijnmr.2024.02.
12. Sajira Buddannavar, Sanjay M. Pirapur, Manjunath G. S. A study to evaluate the effectiveness of an information booklet on knowledge about the management of arteriovenous fistula at home in patients undergoing hemodialysis in selected hospitals in Dharwad District. A and V Pub International Journal of Nursing and Medical Research. 2024; 3(1): 21-24. https:// doi: 10.52711/ijnmr.2024.05.
13. Kalyani K., Sailaja B. Review of analytical methods for bioactive markers used in urolithiasis. Asian Journal of Pharmaceutical Sciences Research. 2022; 12(4): 321-8. https://doi. org: 10.52711/2231-5659.2022.00055.
14. Kauric-Klein Z. Sodium knowledge, beliefs, and behaviors in patients on chronic hemodialysis. Blood Purif. 2020; 49(1–2): 25–32. https://doi. org:10.1159/00050267826.
15. Shraddha. B. Patil, Bhavana. U. Jain, Manish Kondavar. An overview of the problems of drug therapy. Asian J. Res. Pharm. Sci. 2019; 9(2): 137-140. https://doi. org: 10.5958/2231-5659.2019.00020.1
16. Roslyakova E.M., Baizhanova N.S., Igibaeva A.S., Biserova A.G., Alipbekova A.S. Game interactive methods in teaching the discipline "Physiology-2". International Journal of Experimental Education. 2016; 2(2): 295-297.
17. Zhurbenko V.A., Saakyan E.S. Use of Innovative Teaching Methods in a Medical University. International Journal of Applied and Fundamental Research. 2016; 11(1): 161-164.
18. Zarukina E.V. Active teaching methods: recommendations for development and application: teaching aid/ Zarukina E.V., Loginova N.A.,. Novik M. M. SPb. 2010: 59.
19. Dayanova D.D. Application of modern modeling methods to obtain new biological knowledge. Scientific review. Fundamental and applied research. 2023; 1: 101. https://doi. org: scientificreview.ru/ru/article/view?id=101.
20. Dorokhov E.V., Shukurov F.A., Semiletova V.A., Yakovlev V.N., Gorbatenko P.N. Prospects use of active teaching methods at the Department of Normal Physiology of a Medical University. Scientific and Medical Journal “Avicenna Bulletin” of the Tajik State Medical University named after Abuali Ibni Sino. Dushanbe. 2014; 2: 140-143.
21. Tarnovsky D.A. The principle of modeling physiological processes and geometric representation of multimodal sensory data. Bulletin of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences. 2018; 63: 138-145.
22. Bakirova R.E. Innovative technologies in the training of medical students / R.E.Bakirova, S.D.Nursultanova, L.E.Muravleva, K.T.Tusupbekova, Zh.Zh.Turkhanova, B.D.Ashirbekova. Modern problems of science and education. 2018; 3: 69.
23. Modeling human physiology: understanding and application in modern science: 03.11.2023// https://nauchniestati.ru/spravka/modelirovanie-fiziologii-cheloveka.
24. Samir Deruish, Taysir Cheradid, Messauda Gessum. Heavy metals, oxidative stress and inflammation in the pathophysiology of chronic kidney disease - review. Asian J. Pharm. Tech. 2020; 10(3): 202-206. https://doi. org: 10.5958/2231-5713.2020.00033.1.
25. Parvati K.J., Arya B., Sudha M., Sambatkumar R. A study on the analysis of risk factors and prevalence of urolithiasis in tertiary

hospitals in Erode, Tamil Nadu. Res. J. Pharmacology and Pharmacodynamics. 2020; 12(4): 159-162. https://doi. org: 10.5958/2321-5836.2020.00029.4
26. Tokareva A.S., Borovkova N.Yu., Lineva N.Yu., et al. Intradialysis hypertension: emphasis on high dialysis clearance of antihypertensive drugs. Russian scientific journal "Therapy". Moscow. 2023; 3: 28-35. https://doi. org: 10.18565/therapy.2023.3.28-35.
27. Goshiya A. Sheikh. The main roles of technology and analytics in promoting clinical trials. Asian Journal of Pharmaceutical Sciences Research. 2021; 11(2): 155-9. https://doi. org: 10.52711/2231-5659.2021-11-2-11.
28. Mankar S.D., Vaishnavi B. Pawar, Trupti Yu. Pawar. Lipoproteins, cholesterol, treatment strategies and its effect on cardiovascular diseases. Scientific Research Journal of Pharmacology and Pharmacodynamics. 2024; 16(3): 185-1. https://doi. org: 10.52711/2321-5836.2024.00032.
29. Khalkai M.A., Arun Patil, MD Akhil Ahmed, A.K. Beknal. Diuretic activity of Xanthium strumarium L fruit extract in albino rats. Scientific Research Journal of Pharmacology and Pharmacodynamics. 2016; 8(1): January - March, 13-16. https://doi. org: 10.5958/2321-5836.2016.00004.5
30. Sugahara M., Park W.L., Tanaka T., Tang S.W., Nangaku M. . Latest data on the diagnosis, pathophysiology and management of diabetic kidney disease. Nephrol (Carlton). 2021; 26(6): 491–500. https://doi.org/10.1111/nep.13860.
31. Sarnak MJ, Amann K, Bangalore S, Cavalcante JL, Charitan DM, Craig JK. and others//Scientific practical conference. “Chronic kidney disease and coronary heart disease: a review of the current status”. JACC. J Am Coll Cardiol. 2019; 74(14): 1823-1838. https://doi.org/10.1016/j.jacc.2019.08.1017.
32. Shchulkin A.V., Filimonova A.A., Trunina T.P., Pshennikova M.Yu., Brovkin V.V. Pharmacotherapy of arterial hypertension in patients on hemodialysis. Science of the young.- (Eruditio Juvenium). - Ryazan. 2016; 2:26-34.
33. Hemanta Kumar Panigrahi, Srinibash Sahu. Collaborative research to improve health – the researcher's experience. Res. J. Pharmacology and Pharmacodynamics. 2021; 13(1): 27-32. https://doi. org: 10.5958/2321-5836.2021.00006.9.
34. Heaf J., Heiro M., Petersons A. , Werner B., Povlsen J.V., Sorensen A.B., Klein et al. First-year mortality in patients newly admitted to dialysis: results from the Peridialysis Study. BMC Nephrol. 2022; 23(1): 229. https://doi.org/10.1186/s12882-022-02852-1.
35. Rajabova G.B., Khamidova Z.N. Arterial hypertension and kidney damage in women of childbearing age (review article). Science of the young (Eruditio Juvenium). 2016; 2: 139-146.
36. Rhee CM, Ghahremani-Ghajar M, Obi Y, Kalantar-Zadeh K. Incremental and infrequent hemodialysis: a new paradigm for both dialysis initiation and conservative management. Panminerva Med. 2017; 59(2): 188-196. https://doi.org/10.23736/S0031-0808.17.03299-2.
37. Obi Y, Streja E, Rhee CM et al. Incremental Hemodialysis, Residual Kidney Function, and Mortality Risk in Incident Dialysis Patients. A Cohort Study. Am J Kidney Dis. 2016; 68(2): 256-265. https://doi.org/10.1053/j.ajkd.2016.01.008.
38. Morfín JA, Yang A, Wang E, Schiller B. Transitional dialysis care units: A new approach to increase home dialysis modality uptake and patient outcomes//Semin Dial. 2018; 31(1): 82-87. https://doi.org/10.1111/sdi.12651.
39. Afsar B., Turkmen K., Covic A., Kanbay M. An update on coronary artery disease and chronic kidney disease. Int J Nephrol. 2014; 767424. https://doi. org: 10.1155/2014/767424.
40. Poulianiti K.P., Kaltsatou A., Mitrou G. I. et al. Systemic Redox Imbalance in Chronic Kidney Disease: A Systematic Review. Oxid Med Cell Longev.2016; 2016: 8598253. https://doi. org: 10.1155/2016/8598253.
41. Liakopoulos V., Roumeliotis S., Gorny X.et al. Oxidative Stress in Hemodialysis Patients: A Review of the Literature. Oxid Med Cell Longev. 2017; 2017: 3081856. https://doi. org: 10.1155/2017/3081856.
42. Signorini L., Granata S., Lupo A., Zaza G. Naturally Occurring Compounds: New Potential Weapons against Oxidative Stress in Chronic Kidney Disease. Int J Mol Sci. 2017; 18(7): 1481. https://doi. org: 10.3390/ijms18071481.
43. Plavinsky, S.L., Plavinskaya S.I. The role of antioxidants in the treatment and prevention of human diseases. Medicine. 2013; 1: 41-54.
44. Shapovalova E.M., Shidin A.V., Bessonova N.S. Vitamin C and antioxidant protection. International Research Journal. 2017; 04(58); 1: 35-38.
45. Shiksha Jangdeh, Ranjana Arya, Kamaljit Basan, Neeraj Kumar. Preventive measures and suggested recommendations for reducing chemical hazards to the health of medical students and teachers. Scientific Research Journal of Pharmacology and Pharmacodynamics. 2015; 7(3): 147-150. https://doi. org:10.5958/2321-5836.2015.00028.246.
46. Grigoryan R.D. Computer modeling of physiological processors providing human activity: concept and prospects. Conceptual modeling of subject areas. Programming problems. M. 2003; 1: 57-67.
47. Barsuk A.L., Lovtsova L.V., Monakhov A.A. Antioxidant-Type Drugs in Complex Therapy of Patients on Programmed Hemodialysis (Literature Review). News of Higher Educational Institutions. Volga Region. Medical Sciences. 2018; 3 (47): 128–140. https://doi. org: 10.21685/2072-3032-2018-3.
48. Bokeria L.A., Yarustovsky M.B., Bokeria O.L., Biniashvili M.B. Sudden Cardiac Death in Kidney Disease // Arrhythmology Analyses. 2009; 2:39–45.
49. Barsuk A.L., Vozova A.M., Malinok E.V. Evaluation of non-traditional risk factors for cardiovascular pathology in patients undergoing programmed hemodialysis and their drug correction. Modern technologies in medicine. 2012; 4: 171-175.
50. Kato, A. Arterial Stiffening and Clinical Outcomes in Dialysis Patients. A. Kato. Pulse. Basel. 2015; 3(2): 89-97.
51. Kobayashi, S. Cardiovascular Events in Hemodialysis Patients: Challenging against Vascular Calcification. Ann Vasc Dis. 2017; 10 (1): 1-7.
52. Palatkina L.O., Korneeva O.N., Drapkina O.M. Oxidative stress – role in the pathogenesis of chronic heart failure, possibilities of correction. Cardiovascular therapy and prevention. 2012; 11(6): 91–94.
53. Goligorsky, M.S. Pathogenesis of endothelial cell dysfunction in chronic kidney disease: a retrospective and what the future may hold. Kidney Res Clin Pract. 2015; 34 (2): 76–82.
54. Nyyssönen K., Parviainen M.T., Salonen R. et al. Vitamin C Deficiency and Risk of Myocardial Infarction: Prospective Population Study of Men from Eastern Finland.Br. Med. J. 2016; 314: 634–638.
55. Belotserkovsky V.A., Eralina S.N., Kirichenko A.V., Kobzar N.N., Kogai A.L. Efficiency of albumin dialysis in the treatment of hepatorenal failure. https//doi. org: kaznmu.edu.kz/press-2013/12/26/%D1%8D%D1%84% D1%84%D0%B5%D0%BA%D1%.
56. Cice G., Di Benedetto A., D'Isa S., D'Andrea A., Marcelli D., Gatti E., Calabrò R. Effects of telmisartan added to Angiotensin-converting enzyme inhibitors on mortality and morbidity in hemodialysis patients with chronic heart failure a double-blind, placebo controlled trial. J Am Coll Cardiol. 2010; 56(21): 1701-1708.
57. Agarwal R., Sinha A.D. Cardiovascular Protection with Antihypertensive Drugs in Dialysis Patients: A Systematic Review and Meta-analysis. Hypertension. 2019; 53(5): 860-866.
58. Chergizova B.T. Changes in the respiratory system indicators and the leading mechanisms of pathological disorders of the airway patency by workers of the tungsten-molybdenum mine.The European Journal of Pathology. Committees and Organisers 33rd European Congress of Pathology PS-22 Pulmonary Pathology. 2021; 1: 171.
59. Kharissova N., Smirnova L., Kuzmin A., Komkina Y., Salikhova Y. The influence of the physical activity of a modern student on the characteristic of the CVS and RS and their resistance to stress during educational process. «Georgian Medical News». Georgia, 2019; 12(297): 124-129.
60. Marassi, M., Fadini, G.P. The cardio-renal-metabolic connection: a review of the evidence. Cardiovasc Diabetol. 2022; 195 (2023). https:// doi: org/10.1186/s12933-023-01937-x.