CRUSH SYNDROME.
THE AMOUNT OF ASSISTANCE AT THE STAGES OF MEDICAL EVACUATION

Methodical instructions
for the 5th year students to the practical class

МІНІСТЕРСТВО ОХОРОНИ ЗДОРОВ'Я УКРАЇНИ
Харківський національний медичний університет

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СИНДРОМ ДОВГОТРИВАЛОГО ЗДАВЛЕННЯ. ОБСЯГ ДОПОМОГИ НА ЕТАПАХ МЕДИЧНОЇ ЕВАКУАЦІЇ

Методичні вказівки для здобувачів вищої освіти 5-го року навчання до проведення практичного заняття

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Compilers D. Martovytskyi
B. Shelest
O. Sadovenko
V. Brek
V. Prokhorenko
O. Babicheva

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Упорядники Д.В. Мартовицький
Б.О. Шелест
О.Л. Садовенко
В.В. Брек
В.Л. Прохоренко
О.О. Бабічева

Topic 5: «Crush syndrome. Definition. Pathogenesis, classification, clinical manifistations. The amount of assistance at the stages of medical evacuation»

1. Hours: 5

2. Importance of the topic:

Syndrome of traumatic prolonged rhabdomyolysis, compression (STS, crash syndrome, crushing syndrome, traumatic limb compression syndrome, crushing syndrome, compression syndrome, release syndrome, Bywaters syndrome, myorenal syndrome, myoglobinuric nephrosis, ischemic muscle necrosis, etc.) – the body's reaction to endotoxicosis, which develops as a result of ischemic damage to tissues as a result of their mechanical compression, a severe pathological condition that occurs as a result of closed damage to significant areas of soft tissues under the influence of a large and long-lasting mechanical force; which is accompanied by a complex of specific pathological disorders: shock, heart rhythm disorders, acute kidney damage.

The syndrome of prolonged tissue compression is a critical condition that has not yet been sufficiently studied, especially if the release of the compressed limbs is delayed. Obvious scenarios are accidents in mines, tunnels, traffic accidents, accidents, earthquakes and building collapses, terrorist acts. In each of these scenarios, the release can take a long time, usually due to technical issues.

3. Aim of studying: The aim of this theme is be able to expansion and deepening of students' general and medical horizons of knowledge, development of clinical thinking skills, continuation of the formation of the doctor's personality, training of medical professionals to work in emergencies associated with adverse situations.

Specific objectives to be achieved after conducting practical classes

Students need to know:

– classification of rhabdomyolysis depending on the factor that injures;
– simple ways to determine the area and degree of rhabdomyolysis;
– signs of pain shock;
– the volume of first aid for rhabdomyolysis;
– principles of providing PMP during rhabdomyolysis;
– simple ways of transport immobilization of victims and transportation rules;

Students will be able to:

– determine the area and degree of rhabdomyolysis;
– to prevent pain shock;
– provide PMF in case of rhabdomyolysis;
– ensure proper transportation of victims.

4. Indicative syllabus

- Signs and symptoms of rhabdomyolysis
- Causes
- Pathophysiology
- Diagnosis
- Classification
- Differential diagnosis
- Prevention
- Management.
- Prognosis

5. Material and methodological support: Visual material, multimedia devices, visual material prepared presentations of Microsoft Power Point, tables, posters. Training manuals. Regulations Ministry of Health. Special patient.

6. Materials for practical classes:

For the first time, the crash syndrome was described by a surgeon of the Napoleonic army in 1812 in a soldier in a comatose state with necrosis of the skin and muscles as a result of their prolonged compression.

The next report on massive injuries of soft tissues was made by M.I Pirogov in 1864 in the book "Fundamentals of Military Field Surgery". He defined their features as "...traumatic hemorrhages and leaks, tension of tissues, their local deadlock (torpor), compression or pressing."

In 1909, A. Zilberighein described "nephritis with albuminuria" in workers who suffered as a result of prolonged compression of tissues. The definition of the syndrome was made by the French surgeon E. Quenu (1918) during the First World War: in the compression period, the French soldier was in a satisfactory condition, but when the lower limbs were released from the pressing wooden structure, he immediately developed a shock with subsequent death.

In 1941, the British scientist E.G.L. Bywaters, while treating the victims of the bombing of London by German aircraft, studied and isolated this syndrome (which developed in 3.5 % of the victims) into a separate nosological unit, calling it "crush syndrome" (from the English word "crush" – to crush, press).

Among those injured during hostilities in Iraq and Afghanistan, rhabdomyolysis was present in 31.1 % of all hospitalized patients. Based on the materials of the Ashgabat earthquake (1948), M.M. Yelanskyi in 1950 described the clinical picture in detail and determined the basis of treatment of the syndrome of prolonged compression. He proposed to call this condition "traumatic toxicosis", and subsequently optimized the treatment process for rhabdomyolysis in Donbas miners.

Earthquake on Sakhalin in 1995 caused almost simultaneous admission to medical institutions of 95 victims, 89 % of whom developed rhabdomyolysis of various localization, the mortality from it was 17.2 %.

During the earthquake in Marmara (Turkey) in 1999, many children were injured. The specificity of the treatment of Bywaters syndrome in children is due to the fact that their injuries are often much more severe than in adults.

The syndrome of prolonged tissue compression is a critical condition that has not yet been sufficiently studied, especially if the release of the compressed limbs is delayed. Obvious scenarios are accidents in mines, tunnels, traffic accidents, accidents, earthquakes and building collapses, terrorist acts. In each of these scenarios, the release can take a long time, usually due to technical issues.

The prevalence of rhabdomyolysis in road accidents is progressively increasing worldwide and is the second most common cause of death in earthquake victims. As shown by studies of the consequences of natural disasters and other disasters, about 25 % of all victims required inpatient care. Crushing syndrome develops in 30–50 % of cases of traumatic rhabdomyolysis due to seismic disasters.

Of all the wounded from the ATO zone who were treated in intensive care units during the period 2014–2016, 37.9 % had clinical and laboratory signs of rhabdomyolysis and acute respiratory distress syndrome, mostly as a result of a mine-explosive injury.

In 80–90 % of injured people with rhabdomyolysis, the limbs are affected. In the conditions of modern war, as a result of bombing and artillery shelling of populated areas, rhabdomyolysis can reach 5–25 %, as in the case of strong earthquakes. In 60–90 % of all cases of STS, the lower limbs are crushed, 14–20 % – the upper ones. Compression of the head and trunk due to damage to internal organs is usually fatal, but a few cases of full recovery have been reported.

Compression of the head can cause instant death from increased intracranial pressure from bleeding or from skull fracture and direct brain trauma. Static forces pressing on the horizontal anatomical plane cause fractures of the base of the skull, which mostly do not lead to significant lesions of the brain.

Neuroaxonal damage to the brain can be complicated by diabetes insipidus. Victims who have survived an acute period of trauma have a positive long-term neuropsychological prognosis, which reflects the ability of the brain and skull to withstand significant static loads, especially in childhood.

Based on the results of a radioisotope study, it was proven that a pressure of 2.5 kg/cm^2 already stops blood circulation in soft tissues. In the experiment, minimal compression (10 kg/cm^2) for at least 4 hours led to the development of pre-necrotic changes, necrosis of individual fibers, and in some cases – to focal leukocyte infiltration; moderate (25 kg/cm^2) – to pronounced necrotic changes, moderate leukocyte infiltration; at maximum compression (75 kg/cm^2) – total infiltration was added. The pressure of a large load can cause mechanical damage (crushing, crushing) of both soft tissues and bones – crash syndrome. Under the action of smaller loads, tissue ischemia comes to the fore, the degree of which also depends on the time of compression. In such cases, the term should be preferred.

Classification of crash syndrome:

I. By type of compression:

1. Compression by an external force (objects, soil, etc.);
2. Crushing by external force;
3. Positional compression.

II. By localization: upper and lower limbs, their segments.

III. According to the degree of ischemia:

1. Compensated;
2. Decompensated;
3. Irreversible;
4. Gangrene of the limb.

IV. According to the period of the clinical course:

1. Compression period;
2. Post-compression period (early – up to 3 days, intermediate – up to 18 days, late).

V. By the severity of the course: mild, moderate, severe and extremely severe.

On December 7, 1988, at 11:41 local time, a catastrophic earthquake occurred in Armenia. As a result of the earthquake, according to official data, 25,000 people died, more than 15,000 were freed from the rubble alive, 427 victims died of wounds in medical institutions, 140,000 became disabled, and 514,000 people were left homeless. Doctors and rescuers from France, Switzerland, Great Britain, Germany, the USA and other countries arrived in the affected republic. During the period from 9.12. to 14.12.1988, when living victims with earthquake-specific injuries and syndromes that required emergency care were freed from the rubble, the share of victims with STS and SPS combined with general hypothermia was 18.9 % of all injured. At the same time, the problems of the possibility of extracorporeal detoxification immediately arose. The losses of the medical service itself in the earthquake zone amounted to at least 50–60 % of all forces and means. There were sanitary and irreversible losses among the medical and nursing staff.

For the first time in the literature, a classification of severity developed on a huge number of victims appeared – 4 clinical groups taking into account the presence or absence of acute renal failure, combined and combined trauma (I-A, I-B, II-A, II-B) according to the severity of their clinical state.

Medical triage was a priority task, it was carried out according to the following principles: in the first place – determination of the level and assessment of elementary indicators of hemodynamics – pulse, blood pressure. Age norms were determined by an approximate visual assessment (under conditions of stress, local residents "forgot" language, contact with the victims was difficult). With systolic blood pressure < 70 mm Hg, pulse > 100 beats. per minute, the victim was assigned to the shock development group. These victims were sent to the ICU, which were located in the same building on other floors, where other teams (traumatologists, surgeons, general intensive care specialists) performed anti-shock therapy and surgical interventions based on vital indications. After preliminary diagnosis, victims with prolonged compression syndrome were transferred to us from other departments and, sometimes, hospitals in Yerevan. At the same time, several dozen, possibly more, victims arrived, up to 700 people per day. First of all, it was necessary to determine the etiology of anuria. The reasons could be shock, blood loss, or prerenal oligoanuria (alimentary dehydration, as there is no opportunity to drink and eat in constipation). Therefore, in the first few minutes, bladder catheterization and intravenous administration of 1 liter of 0.9 % sodium chloride solution for 1 hour were carried out "behind the conveyor belt".

As for the manipulation of harnesses, when the victims arrived, it was not necessary to remove a single harness, because there were simply none. The wounds (in full) were covered with gauze bandages. There were practically no properly applied tight bandages, they had to be applied in a delayed manner.

After an hour (sometimes, in the case of full staff involvement, later) the quantity and quality of the victim's urine was necessarily assessed. In the absence of oligoanuria, with stable hemodynamic indicators, the victims were sent to therapeutic departments. In the presence of a varnish-brown color or complete absence of urine (which was more common), a diagnosis of rhabdomyolysis was made, and the victim required hemodialysis. Since at that time the opinion prevailed that the best option for connecting to the hemodialysis machine was a Scribner shunt, everyone who remained in the group was immediately put on it, which took about 15–30 minutes.

After the infusion of 1 liter of physiological solution, the victims usually developed swelling of the face, upper and lower limbs (which could be determined visually, because there was no time for a complete physical examination). By this point, the first analyzes have usually already been performed. The main attention was paid to the content of urea and potassium in the blood plasma, which depended on the previous sequence of hemodialysis. At the same time, the infusion of sodium bicarbonate began, but the doses were relatively small – 100–200 ml of a 4 % solution, although an imported 2 % solution was also often used, since the drugs came from all over the world. At that time, we only had solutions in glass bottles, and there we first saw plastic bags from France and other countries. Any available solutions were used for infusion therapy.

For the treatment of victims, the 3rd floor was allocated, where 36 posts of hemodialysis machines were deployed, where perfusion speed, transmembrane pressure and other parameters were controlled with a single center where the dialysis solution was prepared. Patients arrived one by one, who needed to be connected to the device, to choose the heparinization mode (preliminarily – the standard 100–150 IU/kg, and then – with orientation to the blood flow through the air trap (visually, but this technique did not fail us; technical the possibility that there was no possibility of determining the state of blood coagulation in the extracorporeal circuit), the rate of perfusion (visually by blood flow and hemodynamic reaction) is approximately from 40 to 100 ml per minute. The duration of the procedure, as a rule, was standard – 4 hours.

In case of incorrect calculation of the dose for heparinization thrombosis of dialyzers was caused, but this was in isolated cases. Most often, when the device was operating incorrectly, especially in the first minutes of the operation, the hemodynamic parameters dropped to systolic blood pressure of 50–80 mm Hg. Art. In this case, it was necessary to quickly change the operating modes of the apparatus with simultaneous infusion, as a rule, of crystalloid solutions. The tension of the medical staff was very high, as all 36 victims were under control. The machines worked around the clock, 5–6 patients passed through each station per day. Most of the patients underwent hemodialysis once a day, and only in the most severe patients – twice a day. In parallel, specialists from Germany deployed 6 more posts equipped with "Fresenius" devices. At that time, these were one of the best devices both in terms of the efficiency of slag removal and the selection of hemodialysis modes.

Our specialists were not allowed access to them (although they were well versed in this matter), German colleagues did not disclose the characteristics and commercial secrets, they worked for them themselves. As a rule, the most difficult patients were worked on these devices. At the same time, specialists from France assembled 6 more posts equipped with "Hospal" devices. They had little contact with their Soviet colleagues, just like the Germans.

The amount of medical therapy depended entirely on the insufficient material supply. We carried out infusion therapy only with crystalloid solutions (with preservation of zero water balance) with simultaneous stimulation with saluretics in a dose of up to 1 gram day). Non-nephrotoxic antibiotics were used as far as possible. Without extreme need (Hb below 70 g/l), erythrocyte mass was not transfused, freshly frozen native plasma was provided within the limits of drug availability. On the 3rd or 4th day, it became possible to conduct HBO. At the same time, plasmapheresis was started. There was only one "PF-05" and a "RK" centrifuge, the possibilities for plasma substitution were limited.

For this reason, plasmapheresis was performed in a volume of up to 1 liter to replace the exfused plasma only with crystalloids, but this had pathogenetic significance for reducing autosensitization to the own protein compounds of the destroyed muscle tissue. Heparin therapy was carried out as planned in doses of 5,000 IU every 6 hours. after hemodialysis or scheduled after 6 hours. p/sh), because heparin, which was administered for hemodialysis, was naturally inactivated by the time the operation was over.

But the control of blood coagulation was given special importance, because the patients were on hemodialysis every day. For local treatment, elastic bandages were applied to all patients on the first day. At the same time, as the swelling increased, they had to be weakened. It was necessary to monitor the condition of the bandages at least 2 times a day, even if the patient did not complain about the feeling of squeezing. For the purpose of analgesia in these situations, NSAIDs (as a rule, analgin with diphenhydramine) were quite sufficient.

Opioids (promedol, morphine) were used quite rarely. At the stationary stage, it was quite enough to ensure immobility of the limb in bed without splinting. If the patient had fractures, such patients were sent to the trauma department, where traumatologists resolved the issue. The attitude towards the performance of slits was sharply negative. We received several victims after such interventions, all of them developed a picture of severe sepsis on the verge of septic shock for 2–3 days. Such patients were urgently transferred to a separate group (other teams from other cities, less specialized than ours), which dealt with sepsis.

Within the limits of financial possibilities, the patients received drugs with rheological effects (reopoliglucin 200–400 ml per day, trental in a standard dose), hepatotropic therapy (karsyl and glutargin in a standard dose). But hemodialysis remained the main method of treatment. In most patients, as is the case with rhabdomyolysis, the first drops of urine appeared on the 3–4th day and, as the condition stabilized, diuresis resumed, passing into the stage of polyuria. At that time, the general situation had already stabilized, that is, the number of receipts began to decrease. The last surviving victims were pulled out on the 10th day after the earthquake.

By this time, the laboratory service was already well established, so the issue of electrolyte control was resolved. Correction of the water-electrolyte balance was carried out based on the calculation of the deficit.

As soon as control over polyuria was restored (it was no longer 6–8 liters but 2–3 liters), the patients were transferred to the therapeutic department. It should be admitted that we practically did not encounter respiratory distress syndrome and myocardial infarctions in this group of patients.

The main tasks facing an anesthesiologist in the treatment of a wounded person with a mine-explosive injury and the phenomena of rhabdomyolysis are to stop further damage to the mass of muscles, to improve the elimination of tissue decay products, without burdening the patient's condition, while continuing to prosthetic vital functions, anti-shock measures and rehabilitation of the focus of myolysis, prevent the development of purulent-septic complications. A multidisciplinary approach and "damage control" are the foundation of recovery of the wounded.

Hyperkalemia and metabolic acidosis, which is difficult to correct, are factors that directly threaten the life of the patient, which require an urgent decision to carry out correction. A large number of tissue decay products as a result of their ischemia or direct damage leads to gross changes in nitrogen metabolism, hyperproductive azotemia, hyperosmolarity, pathology of the hemostasis system, and the progression of multiple organ failure syndrome.

Techniques aimed at eliminating myolysis products can be conditionally divided into two groups. The first group is the replacement of the liquid part of the blood, in which there are tissue decay products, the second is the cleaning of the liquid part of the blood from decay products. In the 21st century, medical practice completely abandoned the idea of blood replacement as an effective method of combating intoxication, realizing the low efficiency of blood transfusions and exchange transfusions, which caused the greatest danger to the patient.

The method of replacing the liquid part of blood (plasma) – plasmapheresis – has shown insufficient effectiveness in rhabdomyolysis, since for a significant reduction of substances dissolved in plasma by 75 %, it is necessary to replace 150 % of the volume of circulating plasma, which is already plasma exchange. The absolute requirements for performing plasma exchange are multicomponent replenishment of the volume of circulating plasma: albumin to maintain iso-oncoticity of plasma and coagulation factors to prevent hemorrhagic complications.

The issue of decreased immunity due to the loss of immunoglobulins, a decrease in the concentration of medical drugs and hormones in the blood remains open. The plasma exchange method contradicts the "damage control" strategy, exposing an unstable patient in critical condition to additional danger. Plasma exchange is a rather aggressive method for the patient, very expensive, and most importantly, it does not solve the issue of effective removal of decay products that are dissolved in the water sector of the body, but do not circulate in the vascular bed.

The use of anticoagulants during plasma exchange in combat trauma patients with unstable hemostasis with simultaneous removal of coagulation factors can lead to bleeding. In view of the above, the method of plasma exchange for rhabdomyolysis in the wounded with combat trauma was used infrequently in our practice, only in cases of adequate rehabilitation of the focus of myolysis against the background of reliable hemostasis.

For example, amputation of a crushed limb was performed with preserved kidney function and stable hemodynamics. The use of plasmapheresis in this case ensured almost complete elimination of tissue decay products, and the technique was usually performed once. Methods aimed at cleaning the liquid part of the blood can also be conditionally divided into two groups according to the duration of the procedure – continuous and intermittent (intermittent). Long-term methods do not allow to quickly eliminate components that are harmful to the patient. So, for example, with critical hyperkalemia, such methods are not suitable, in this case, it is necessary to use an intermittent method for removing low molecular weight components – dialysis.

However, continued methods are less aggressive and safely reduce the concentration of nitrogenous slags, which does not lead to the ricochet syndrome – "disequilibrium syndrom" – which is a dangerous complication of dialysis. When the level of urea and plasma osmolality decreases, the redistribution of water in the tissues is disturbed, which can lead to brain edema. Extended methods can be used in case of unstable hemodynamics.

The criterion for determining the method of renal replacement therapy in the treatment of wounded patients with renal failure and signs of rhabdomyolysis is the effect on the leading **pathogenetic factor:**

1. Correction of hypervolemia.
2. Correction of hyperkalemia.
3. Correction of acidosis.
4. Correction of hyperazotemia.
5. Correction of hypernatremia.

In most cases, kidney function was restored. Timely started and adequately conducted anti-shock therapy was the main measure of prevention of the development of acute kidney damage in patients with rhabdomyolysis. Sanitation of the focus of myolysis in rhabdomyolysis led to faster stabilization of vital functions and restoration of kidney function.

Emergency aid. Crash syndrome is one of the vivid examples of pathological conditions in which the correctness of providing medical care at each stage can determine the patient's fate. Narcotic analgesics are administered to the victim at the scene before release from compression, and if rapid release is not possible, infusion anti-shock therapy is started without elimination of compression.

Immediately before pulling out the limb from under the object that determines the compression, a temporary tourniquet is placed on it. Immediately after extraction, the viability of the limb is assessed:

• with compensated and decompensated ischemia, the tourniquet is removed,

• with irreversible ischemia and crushing of the limb – it is subject to amputation – the tourniquet is not removed or transferred to the border of non-viable tissues.

Failure to comply with the provision of temporary application of a tourniquet before assessing the viability of the limb can cause fatal complications and the death of the victim. At the same time, it is not permissible to leave the tourniquet on the limb if its non-viability is doubtful, since the lack of blood circulation during the next evacuation can lead to irreversible changes in the tissues and be the cause of amputation, which could be avoided. Leaving the tourniquet in compensated and uncompensated ischemia is indicated only to stop bleeding from the main arteries.

With compensated and uncompensated ischemia, after removing the tourniquet, aseptic bandages are applied to the wounds, tight elastic bandages are performed in the distal direction, and transport immobilization and cooling of the limb are provided. Elastic bandaging allows to reduce the intensity of reperfusion toxemia and the occurrence of tourniquet shock when the circulation is "turned on". In addition, moderate compression of soft tissues reduces venous blood deposition and limb swelling.

Transportation of the victim to the hospital should be carried out in the supine position with the provision of analgesia, immobilization and anti-shock infusion therapy. The patient is indicated for volume enteral use of alkaline solutions.

Tactics and treatment. Immediately after hospitalization, treatment measures should be aimed at solving the following tasks:

• bringing the patient out of shock, stabilizing hemodynamics and breathing;

• performing surgical interventions for emergency and urgent indications (cavity interventions, limb amputations, necroctomies and fasciotomies, extra-focal osteosynthesis);

• correction of acidosis and hyperkalemia, water-electrolyte balance;

• detoxification (hemodilution – forced diuresis, extracorporeal methods – plasmapheresis, hemosorption, hemodialysis);

• symptomatic therapy.

7. <u>Main questions to be studied in this lesson</u>

1. Causes of prolonged compression syndrome, synonyms of the name.
2. Triggering mechanisms of disease development (pathogenesis).
3. Is crushing an open or closed type of injury?
4. What is the difference between prolonged compression syndrome and positional compression syndrome?
5. Why can rhabdomyolysis develop in operating conditions?
6. What level of basal temperature in rhabdomyolysis is characterized by 100 % lethality?
7. What is the protective role of tissue swelling in rhabdomyolysis?
8. What conditions does the "lethal triad of trauma" include?
9. What is the "golden hour rule"?
10. Define the term "saving death".
11. When are the turnstiles removed after release, and when are they not?
12. What complication can large volumes of injected sodium chloride solution lead to?

13. What method should be used to assess the sensitivity of the victim to the injected volumes of liquid?

14. What could be the negative consequences of using mannitol in rhabdomyolysis?

15. Name the nephrotoxic substances that are formed during compression (crushing) of the muscles of crushed limbs.

16. What is the peculiarity of the algorithm for providing medical assistance when identifying a person affected by rhabdomyolysis?

17. Why does oliguria develop, and then anuria?

18. What can be combinations of rhabdomyolysis?

19. When prolonged compression may not cause rhabdomyolysis?

20. What should be the first measure to be taken before evacuating the victims from under the rubble?

8. List of practical skills

1. First aid for victims of rhabdomyolysis. (algorithm for providing first aid, thermal insulation bandage).

2. Determination of the area and degree of rhabdomyolysis.

3. First aid to victims, depending on the degree of rhabdomyolysis in emergency situations in peacetime and in combat conditions.

4. First aid in case of defeat rhabdomyolysis.

9. References and recommended reading:

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Навчальне видання

СИНДРОМ ДОВГОТРИВАЛОГО ЗДАВЛЕННЯ. ОБСЯГ ДОПОМОГИ НА ЕТАПАХ МЕДИЧНОЇ ЕВАКУАЦІЇ

Методичні вказівки для здобувачів вищої освіти 5-го року навчання до проведення практичного заняття

Упорядники Мартовицький Дмитро Володимирович
Шелест Борис Олексійович
Садовенко Ольга Леонідівна
Брек Валерія Василівна
Прохоренко Василій Леонтійович
Бабічева Олександра Олександрівна

Відповідальний за випуск Д.В. Мартовицький

Комп'ютерна верстка О.Ю. Лавриненко

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Редакційно-видавничий відділ
ХНМУ, пр. Науки, 4, м. Харків, 61022
izdatknmurio@gmail.com, vid.redact@knmu.edu.ua

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