зумовлені підвищеною функціональною активністю навколосудиннних мастоцитів, які регулюють перебіг алергічного запального процесу за рахунок впливу на судинну та клітинну реакції.

Ключові слова: гемомікроциркуляторне русло, експериментальне алергічне запалення, овальбумін, морська свинка, електронна мікроскопія.

MICROSCOPIC AND SUBMICROSCOPIC CHANGES IN THE HEMOMICROCIRCULATORY BED OF THE LUNGS IN THE CONDITIONS OF EXPERIMENTAL ALLERGIC INFLAMMATION

Popko S. S.

Abstract. Considering the important role of the hemomicrocirculatory bed of the lungs for maintaining local homeostasis of the respiratory system, the study of its ultramicroscopic features in case of the allergic inflammatory process in the lungs is one of the urgent tasks of morphology.

The aim of this work is to determine the main microscopic and submicroscopic changes in the hemomicrocirculatory bed of the lungs under conditions of experimental allergic inflammation.

Material and methods. Using histological and electron microscopic methods, the lungs of 48 male guinea pigs were studied under conditions of experimental ovalbumin-induced allergic inflammation. We determined ultrastructural changes in the components of the hemomicrocirculatory bed under conditions of experimental allergic inflammation.

Results. The regularity of the reaction of the structural components of the hemomicrocirculatory bed in response to ovalbumin sensitization and inhalation was revealed, consisted in the structural and functional reorganization of the vessels of the exchange link of the microcirculatory bed of the lungs of ovalbumin-sensitized guinea pigs in the form of plethora, vasodilatation, increasing permeability of the vascular wall, which leads to edema and disorganization of perivascular connective tissue. swelling of the endothelial cells of the vessels of the hemomicrocirculatory bed, therefore a large number of microprotrusions and intussusceptions are formed, as a result of which the shape of the vascular lumen changed.

Conclusions. It was established that during the early period of the development of the allergic inflammatory process in the lungs, there are signs of dysfunction of the endothelium of the hemomicrocirculatory channel and increased permeability of the vascular wall, confirmed at the ultramicroscopic level. The detected hemomicrocirculatory changes are due to the increased functional activity of perivascular mast cells, which regulate the course of the allergic inflammatory process due to the influence on vascular and cellular reactions.

Key words: hemomicrocirculatory bed, experimental allergic inflammation, ovalbumin, guinea pig, electron microscopy.

ORCID автора та його внесок до статті:
Popko S. S.: 0000-0002-5533-4556 [ABCDEF]

Адреса для кореспонденції
Попко Світлана Сергіївна
Запорізький державний медичний університет
Адреса: Україна, 69035, м Запоріжжя, пр-т Маяковського 26
Тел.: +380502614594
E-mail: kluchkosv@gmail.com

A – концепція роботи та дизайн, **B** – збір та аналіз даних, **C** – відповідальність за статичний аналіз, **D** – написання статті, **E** – критичний огляд, **F** – остаточне затвердження статті.

Стаття надійшла 20.03.2022 року
Стаття прийнята до друку 06.09.2022 року

DOI 10.29254/2077-4214-2022-3-166-450-456
UDC 611.716.4-001-018.4: 612.015.31: 615.212.7: 615.33] -08

Sohuyko R. R., Masna Z. Z., Rudnytska Kh. I., Dachno L. O., Chelpanova I. V., Fik V. B.

ANALYSIS OF POST-TRAUMATIC DYNAMICS OF MINERAL COMPOSITION OF BONE TISSUE IN INTACT ANIMALS ON THE BACKGROUND OF THE PROLONGED NALBUFINUM USE AND AFTER LINCOMYCIN TREATMENT

Danylo Halytsky Lviv National Medical University (Lviv, Ukraine)
kristinarudnytska@gmail.com

The mineral composition of the bone tissue can be affected by different factors. Nowadays, one of the most negative influences on the mineral content of the osseous tissue can be given to the influence narcotic analgesics such as Nalbufinum. That's why the aim of our study was to find out the peculiarities of dynamics of the mineral composition of the mandibular bone tissue after bone destructive trauma in animals without background pathology, on the background of the prolonged Nalbuphinum use and after treatment with Lincomycin. The study was performed on 25 sexually mature male rats. Injury was modeled by breaking the integrity of the mandibular bone tissue in the area of molars with the help of dental drill. Opioid dependence was modeled by administering narcotic analgesic *nalbuphinum daily. Atomic absorption spectral analysis (AACA) method was used to determine the mineral composition. The content of different mineral elements was different during the time of the experiment in different groups of the animals and had the expressed dynamics, characteristic for each stage of the experiment. After the application of bone-destructive trauma, the mineral composition of the bone tissue during three weeks has an expressed dynamic different for each of the eight studied mineral elements. The dynamics of the studied mineral elements during three-week post-traumatic period in animals without background pathology, on the background of prolonged nalbuphinum use and animals that were treated with lincomycin is different.*

Key words: *bone tissue, nalbuphinum, mineral composition, bone-destructive trauma.*

Connection of the publication with planned research works. The results of the article correspond to the research plan of Danylo Halytsky Lviv National Medical University and are part of the scientific work of the Normal Anatomy Department and Operative Surgery and Topographic Anatomy Department "Morphofunctional features of organs in the pre – and postnatal periods of ontogenesis, under the influence of opioids, food additives, reconstructive surgery and obesity" (state registration number 0120U002129).

Introduction. The mineral composition of bone tissue is affected by various factors of local and general action – trauma, background diseases, which are accompanied by metabolic changes, chronic intoxication, prolonged use of medications, etc [1-6]. Today, analgesics are widely used in various fields of medicine [7-13]. Numerous scientific works are devoted to the study of their influence on the morphological features of the organs of the central and peripheral nervous, cardiovascular, digestive, respiratory, urogenital, endocrine systems [12-19].

The aim of our study was to find out the peculiarities of dynamics of the mineral composition of the mandibular bone tissue after bone traumatic injury in animals without background pathology, on the background of the prolonged Nalbuphinum use and after treatment with Lincomycin.

Object and research methods. The study was performed on 25 sexually mature male rats with a body weight of 180-200 g and 3.5 months old. All animals were divided into 5 groups [20-21]:

Group 1 – intact animals which underwent bone-destructive trauma.

Group 2 – intact animals which underwent bone-destructive trauma and then were treated with Lincomycin.

Group 3 – animals which underwent bone-destructive trauma after three weeks of Nalbuphinum use.

Group 4 – animals which underwent bone-destructive trauma after three weeks of Nalbuphinum use and subsequent treatment with Lincomycin.

Group 5 – control.

The experimental animals were kept in the vivarium conditions of the Danylo Halytsky Lviv National Medical University. All studies were carried out in accordance with the provisions of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986), Council of Europe Directive 86/609 / EEC (1986), Law of Ukraine No. 3447-IV "On the Protection of Animals from Cruelty Handling".

Injury was modeled by breaking the integrity of the mandibular bone tissue in the area of molars with the help of dental drill. The manipulation was performed under thiopental anesthesia [8].

Opioid dependence was modeled by administering narcotic analgesic nalbuphinum daily (1 time per day). Nalbufinum was injected intramuscularly according to the following schedule: 1st week – 8 mg/kg, 2nd – 15 mg/kg, 3rd – 20 mg/kg, 4th – 25 mg/kg, 5th – 30 mg/kg, 6 mg – 35 mg/kg.

Lincomycin (30% solution) was administered intraperitoneally at a dosage of 25 mg/kg once a day for 6 days after injury.

Atomic absorption spectral analysis (AACA) method was used to determine the mineral composition of the bone of the lower jaw of the rat, which made it possible to detect in the samples the content of eight mineral elements (four of which were macroelements: calcium (Ca), phosphorus (P), magnesium (Mg), sodium (Na) and four microelements: potassium (K), iron (Fe), strontium (Sr), zinc (Zn). The concentration of the studied elements in bone samples was indicated in mg/g. Studies of the mineral composition of the lower jaw bone tissue were performed 1, 2, and 3 weeks after injury.

Table 1 – The content of mineral elements in the bone tissue of the rat mandible in norm and after bone-destructive trauma (mg/g)

		Ca	P	Na	Mg	K	Fe	Sr	Zn
Intact animals	Middle value M	14,0067	11,56333	2,4333	2,7867	2,9533	0,45	0,2	0,1567
	Left border of confidence interval M-Δ	13,7925	10,28278	2,0539	2,2525	2,8413	0,3258	0,0758	0,0942
	Right border of confidence interval M-Δ	14,2208	12,84389	2,8128	3,3208	3,0653	0,5742	0,3242	0,2192
1-st week after trauma	Middle value M	40,0633	14,36	2,3767	2,2467	1,6767	0,9567	0,22	0,3167
	Left border of confidence interval M-Δ	38,0003	13,61476	2,2647	2,1216	1,5249	0,9187	0,0958	0,2787
	Right border of confidence interval M-Δ	42,1264	15,10524	2,4887	2,3717	1,8284	0,9946	0,3442	0,3546
2-nd week after trauma	Middle value M	38,2	14,96	2,7167	2,35	2,21	0,7133	0,19	0,1767
	Left border of confidence interval M-Δ	37,0616	14,69828	2,5159	1,8086	2,0128	0,6754	0,0658	0,1387
	Right border of confidence interval M-Δ	39,3384	15,22172	2,9175	2,8914	2,4072	0,7513	0,3142	0,2146
3-rd week after trauma	Middle value M	41,7667	14,30333	3,1467	2,58	2,0967	0,8	0,2	0,27
	Left border of confidence interval M-Δ	39,2825	13,58279	2,8834	2,5303	1,9469	0,7503	0,0758	0,2452
	Right border of confidence interval M-Δ	44,2508	15,02388	3,41	2,6297	2,2464	0,8497	0,3242	0,2948

Table 2 – The content of mineral elements in the bone tissue of the body of the rat mandible in norm and after bone-destructive trauma and treatment with lincomycin (mg/g)

		Ca	P	Na	Mg	K	Fe	Sr	Zn
Intact animals	Middle value M	14,0067	11,56333	2,4333	2,7867	2,9533	0,45	0,2	0,1567
	Left border of confidence interval M-Δ	13,7925	10,28278	2,0539	2,2525	2,8413	0,3258	0,0758	0,0942
	Right border of confidence interval M-Δ	14,2208	12,84389	2,8128	3,3208	3,0653	0,5742	0,3242	0,2192
1-st week after trauma	Middle value M	36,42	121,0667	1,8333	2,31	1,28	0,43	0,2	0,23
	Left border of confidence interval M-Δ	36,084	118,4573	1,7461	2,2852	1,0259	0,3058	0,0758	0,2052
	Right border of confidence interval M-Δ	36,756	123,676	1,9206	2,3348	1,5341	0,5542	0,3242	0,2548
2-nd week after trauma	Middle value M	37,65	113,1667	1,9	3,0433	1,42	0,62	0,2	0,17
	Left border of confidence interval M-Δ	35,5438	111,6693	1,8752	2,8817	1,2325	0,5952	0,0758	0,1452
	Right border of confidence interval M-Δ	39,7562	114,664	1,9248	3,205	1,6075	0,6448	0,3242	0,1948
3-rd week after trauma	Middle value M	41,6933	126,4667	2,5367	2,08	2,0467	1,0467	0,2133	0,1733
	Left border of confidence interval M-Δ	39,4623	125,2163	2,3126	1,9806	1,9216	0,9216	0,0765	0,1354
	Right border of confidence interval M-Δ	43,9244	127,717	2,7607	2,1794	2,1717	1,1717	0,3501	0,2113

Table 3 – The content of mineral elements in the bone tissue of the body of the rat mandible in norm and after bone-destructive trauma on the background of nalbuphinum use (mg/g)

		Ca	P	Na	Mg	K	Fe	Sr	Zn
Intact animals	Middle value M	14,0067	11,56333	2,4333	2,7867	2,9533	0,45	0,2	0,1567
	Left border of confidence interval M-Δ	13,7925	10,28278	2,0539	2,2525	2,8413	0,3258	0,0758	0,0942
	Right border of confidence interval M-Δ	14,2208	12,84389	2,8128	3,3208	3,0653	0,5742	0,3242	0,2192
After 3 weeks of nalbufinum use	Middle value M	41,7667	14,30333	3,1467	2,58	2,0967	0,8	0,190	0,27
	Left border of confidence interval M-Δ	39,2825	13,58279	2,8834	2,5303	1,9469	0,7503	0,0658	0,2452
	Right border of confidence interval M-Δ	44,2508	15,02388	3,41	2,6297	2,2464	0,8497	0,3142	0,2948
1-st week after trauma	Middle value M	43,8633	12,39333	3,0300	2,7433	1,0400	0,7533	0,2000	0,3033
	Left border of confidence interval M-Δ	43,3022	11,53772	2,9555	2,6561	0,7879	0,6036	0,0758	0,2408
	Right border of confidence interval M-Δ	44,4245	13,24895	3,1045	2,8306	1,2921	0,9031	0,3242	0,3658
2-nd week after trauma	Middle value M	40,29	11,54667	2,07	2,5567	1,3867	0,4467	0,2	0,24
	Left border of confidence interval M-Δ	39,7555	11,39693	1,8961	2,1829	1,2994	0,3216	0,0758	0,1903
	Right border of confidence interval M-Δ	40,8245	11,6964	2,2439	2,9304	1,4739	0,5717	0,3242	0,2897
3-rd week after trauma	Middle value M	38,5267	11,52	2,55	2,7333	1,6633	0,67	0,2	0,3233
	Left border of confidence interval M-Δ	36,1639	10,36468	2,4258	2,4208	1,5221	0,6203	0,0758	0,2854
	Right border of confidence interval M-Δ	40,8894	12,67532	2,6742	3,0459	1,8046	0,7197	0,3242	0,3613

Table 4 – The content of mineral elements in the bone tissue of the rat mandible in norm and after bone-destructive trauma and treatment with lincomycin on the background of nalbuphinum use (mg/g)

		Ca	P	Na	Mg	K	Fe	Sr	Zn
Intact animals	Middle value M	14,0067	11,56333	2,4333	2,7867	2,9533	0,45	0,2	0,1567
	Left border of confidence interval M-Δ	13,7925	10,28278	2,0539	2,2525	2,8413	0,3258	0,0758	0,0942
	Right border of confidence interval M-Δ	14,2208	12,84389	2,8128	3,3208	3,0653	0,5742	0,3242	0,2192
After 3 weeks of nalbufinum use	Middle value M	41,7667	14,30333	3,1467	2,58	2,0967	0,8	0,2	0,27
	Left border of confidence interval M-Δ	39,2825	13,58279	2,8834	2,5303	1,9469	0,7503	0,0758	0,2452
	Right border of confidence interval M-Δ	44,2508	15,02388	3,41	2,6297	2,2464	0,8497	0,3242	0,2948
1-st week after trauma	Middle value M	38,52	14,03	2,16	2,3733	1,0567	0,9033	0,21	0,72
	Left border of confidence interval M-Δ	38,1051	13,4818	2,0606	2,0209	0,8454	0,8654	0,0858	0,6952
	Right border of confidence interval M-Δ	38,9349	14,5782	2,2594	2,7258	1,2679	0,9413	0,3342	0,7448
2-nd week after trauma	Middle value M	42,84	10,66333	2,0333	2,1767	1,2067	0,5467	0,22	0,32
	Left border of confidence interval M-Δ	42,3183	10,52652	1,8965	1,7157	1,0322	0,4216	0,0958	0,2952
	Right border of confidence interval M-Δ	43,3617	10,80015	2,1701	2,6376	1,3811	0,6717	0,3442	0,3448
3-rd week after trauma	Middle value M	42,2633	10,44333	3,14	2,9633	2,08	0,71	0,18	0,26
	Left border of confidence interval M-Δ	40,04	10,28171	2,991	2,8629	1,9904	0,5361	0,0558	0,2352
	Right border of confidence interval M-Δ	44,4866	10,60496	3,289	3,0637	2,1696	0,8839	0,3042	0,2848

Research results and their discussion. The analysis of the mineral composition of the bone tissue of the lower jaw of the rat in norm and within three weeks after the application of bone-destructive trauma allowed to determine the quantitative content of all the investigated elements in the bone tissue at each of the stages of the experiment and confirmed the presence of their expressed dynamics in each of the groups of the experiment **(tables 1-4)**.

Analysis of the calcium content dynamics in different experimental groups showed that after trauma in intact animals, it increased more than twice and continued to increase slightly until the end of the experiment **(tables 1-4, fig. 1)**. In the animals of the 3rd and 4th experimental groups, which were given nalbuphinum for three weeks at the time of trauma, the calcium content was almost three times higher than in norm at the time of trauma. At the end of the third week after injury in the animals of 3rd group calcium content decreased slightly, in the animals of 4th group – increased slightly **(tables 1-4, fig. 1)**.

Phosphorus content in animals of the 3rd and 4th groups at the beginning of the experiment was higher than in the intact animals, but at the end of the third week of the experiment it decreased to norm, and in the animals of the 1st and 2nd group it increased slightly, more – in animals which were not treated with lincomycin **(tables 1-4, fig. 2)**.

Sodium content in bone tissue of animals of 3rd and 4th groups was higher in animals which were given nalbuphinum than that of intact animals. In the animals of the 1st and 2nd groups, the sodium content decreased during the first week of the experiment and increased during the next two, in the animals of the 3rd and 4th groups it decreased during two weeks and increased by the end of the third. At the end of the experiment, the sodium content in the 1st and 2nd groups was higher than in the 3rd and 4th groups **(tables 1-4, fig. 3)**.

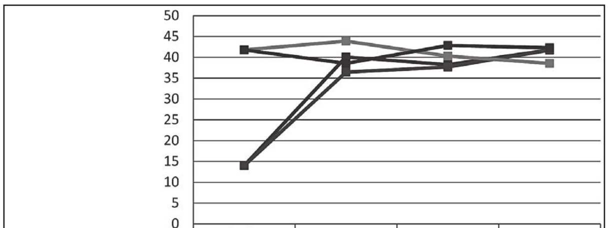
Analysis of the magnesium content in bone tissue showed that after three weeks of nalbuphinum intake, it only slightly decreased compared to the norm **(tables 1-4, fig. 4)**. After trauma, the most stable indicator of magnesium content was in animals of 3rd group, and the most expressed dynamics was observed in animals of 2nd group. At the end of the experiment, the magnesium content in the animals of 3rd group returns to norm, in the animals of the 1st and 2nd groups decreases, and in the animals of the 4th group – increases **(tables 1-4, fig. 4).**

The content of potassium in bone tissue on the background of nalbuphinum intake is lower than in norm **(tables 1-4, fig. 5)**. In all groups, this indicator sharply decreases at the end of the first week of the experiment with subsequent growth, and three weeks after the injury remains below norm, with the lowest rate in animals of 3rd group **(tables 1-4, fig. 5)**.

The iron content of the animals of 3rd and 4th groups at the time of injury was twice higher than in animals of 1st and 2rd groups. After trauma, the dynamics of the studied indicator in animals of different groups was different, and at the end of the third experimental week, the content of iron in bone tissue in animals of all groups was significantly higher than in norm. In the 2nd group, the iron content increased almost three times, in the 1st group – twice in comparison with the norm, and in the 3rd and 4th groups it exceeded the norm, but was lower than at the moment of the injury **(tables 1-4, fig. 6)**.

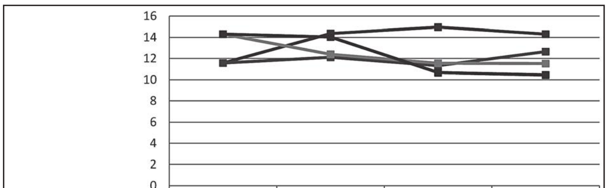
The content of strontium in the bone tissue of animals of all experimental groups at the time of injury and its dynamics during the experiment differed minimally **(tables 1-4, fig. 7)**.

The amount of zinc in the bone tissue of the 3rd and 4th groups was higher than in norm. The dynamics of its contents were similar: it increased by the end of the first week, decreased during the second and increased again by the end of the experiment in animals of the 1st, 2nd and 3rd groups, and in the animals of the 4th group continued to decrease until the end of the third week. At the end of the experiment, the zinc content in the bone tissue of animals of all groups was higher than in norm, with minimal difference in group 2 and highest in group 3 **(tables 1-4, fig. 8)**.



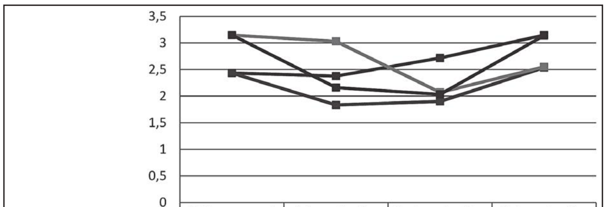
	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	14,0067	40,0633	38,2	41,7667
Trauma+Lincomicinum	14,0067	36,42	37,65	41,6933
Nalbuphinum+trauma	41,7667	43,8633	40,29	38,5267
Nalbuphinum+trauma +Lincomicinum	41,7667	38,52	42,84	42,2633

Figure 1 – Dynamics of calcium content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).



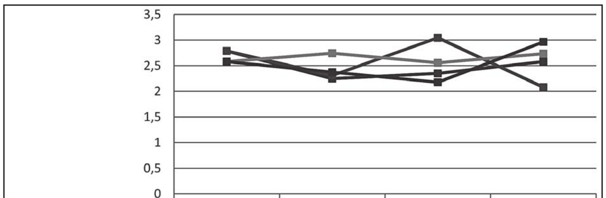
	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	11,56333	14,36	14,96	14,30333
Trauma+Lincomicinum	11,56333	12,10667	11,31667	12,64667
Nalbuphinum+trauma	14,30333	12,39333	11,54667	11,52
Nalbuphinum+trauma +Lincomicinum	14,30333	14,03	10,66333	10,44333

Figure 2 – Dynamics of phosphorus content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).



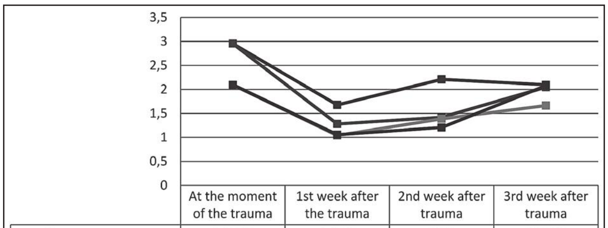
	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	2,4333	2,3767	2,7167	3,1467
Trauma+Lincomicinum	2,4333	1,8333	1,9	2,5367
Nalbuphinum+trauma	3,1467	3,03	2,07	2,55
Nalbuphinum+trauma +Lincomicinum	3,1467	2,16	2,0333	3,14

Figure 3 – Dynamics of sodium content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).



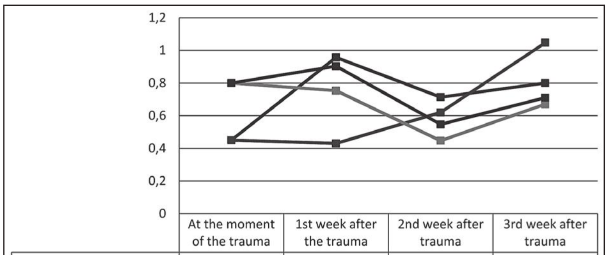
	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	2,7867	2,2467	2,35	2,58
Trauma+Lincomicinum	2,7867	2,31	3,0433	2,08
Nalbuphinum+trauma	2,58	2,7433	2,5567	2,7333
Nalbuphinum+trauma +Lincomicinum	2,58	2,3733	2,1767	2,9633

Figure 4 – Dynamics of magnesium content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).



	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	2,9533	1,6767	2,21	2,0967
Trauma+Lincomicinum	2,9533	1,28	1,42	2,0467
Nalbuphinum+trauma	2,0967	1,04	1,3867	1,6633
Nalbuphinum+trauma +Lincomicinum	2,0967	1,0567	1,2067	2,08

Figure 5 – Dynamics of potassium content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).



	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	0,45	0,9567	0,7133	0,8
Trauma+Lincomicinum	0,45	0,43	0,62	1,0467
Nalbuphinum+trauma	0,8	0,7533	0,4467	0,67
Nalbuphinum+trauma +Lincomicinum	0,8	0,9033	0,5467	0,71

Figure 6 – Dynamics of iron content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).

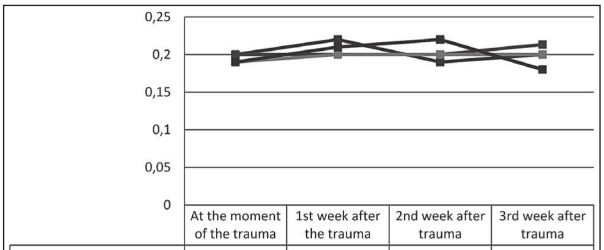
During our study, we found peculiarities of the mineral composition dynamics of the bone tissue of the rats mandible after bone-destructive trauma in animals without background pathology, on the background of long-term Nalbuphinum use and after treatment with Lincomycin in absolute values. The obtained results confirm the literature data on changes in organs and tissues under the influence of Nalbuphinum and may form the basis for the development of new and improvement of existing methods of treatment and prevention of complications of bone fractures in persons with background drug dependence or long-term treatment with the opioid drugs use.

Conclusions.

After the application of bone-destructive trauma, the mineral composition of the bone tissue during three weeks has an expressed dynamic different for each of the eight studied mineral elements (Ca, P, Mg, Na, K, Fe, Sr, Zn).

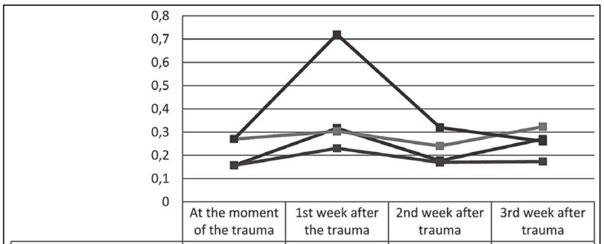
The dynamics of the studied mineral elements during three-week post-traumatic period in animals without background pathology, on the background of prolonged nalbuphinum use and animals that were treated with lincomycin is different.

Prospects for further research. Our study of the peculiarities of dynamics of the mineral composition of the mandibular bone tissue after bone destructive trauma on the background of the prolonged Nalbuphinum use and after treatment with Lincomycin will provide an opportunity to conduct and evaluate a similar correction in the distant terms of opioid influence and compare the data obtained regarding the corrective effect of these indicators in dynamics.



	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	0,2	0,22	0,19	0,2
Trauma+Lincomicinum	0,2	0,2	0,2	0,2133
Nalbuphinum+trauma	0,19	0,2	0,2	0,2
Nalbuphinum+trauma +Lincomicinum	0,19	0,21	0,22	0,18

Figure 7 – Dynamics of strontium content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).



	At the moment of the trauma	1st week after the trauma	2nd week after trauma	3rd week after trauma
Trauma	0,1567	0,3167	0,1767	0,27
Trauma+Lincomicinum	0,1567	0,23	0,17	0,1733
Nalbuphinum+trauma	0,27	0,3033	0,24	0,3233
Nalbuphinum+trauma +Lincomicinum	0,27	0,72	0,32	0,26

Figure 8 – Dynamics of zinc content in the bone tissue of the mandible of animals of different experimental groups within three weeks after injury (mg/g).

References

1. Elhennawy K, Manton DJ, Crombie F, Zaslansky P, Radlanski RJ, Jost-Brinkmann P, et al. Structural, mechanical and chemical evaluation of molar-incisor hypomineralization-affected enamel: a systematic review. **Arch Oral Biol.** 2017;83:272-281. DOI: 10.1016/j.archoralbio.2017.08.008.
2. Fik V, Kovalyshyn O, Paltov Y, Kryvko Y. Submicroscopic organization of the periodontium with experimental six-week opioid action and medicinal correction. Georgian Med News. 2019;296:107-111.
3. Iero PT, Mulherin DR, Jensen O, Berry T, Danesi H, Razzok SJ. A Prospective, Randomized, Open-Label Study Comparing an Opioid-Sparing Postsurgical Pain Management Protocol With and Without Liposomal Bupivacaine for Full-Arch Implant Surgery. Int J Oral Maxillofac Implants. 2018;33(5):1155-1164. DOI: 10.11607/jomi.5938.
4. Xi MY, Li SS, Zhang C, Zhang L, Wang T, Yu C. Nalbuphine for Analgesia After Orthognathic Surgery and Its Effect on Postoperative Inflammatory and Oxidative Stress: A Randomized Double-Blind Controlled Trial. J Oral Maxillofac Surg. 2020;78(4):528-537. DOI: 10.1016/j.joms.2019.10.017.
5. Diskovskyi IS. Reparative processes of the skin under influence of opioid in experiment. Folia Medica Cassoviensia. 2015;70(1):27-28.
6. Volkow ND, McLellan AT. Opioid abuse in chronic pain – misconceptions and mitigation strategies. N. Engl. J. Med. 2016;374:1253-1263.
7. Hresko NI. Changes of colon angioarchitectonics under conditions of 2-4-week opioid effect in the experiment. Deutscher Wissenschaftsherold. German Science Herald. 2017;5:43-48.
8. Sohuyko R, Pavliv K, Masna-Chala O, Diskovskyi I, Mana Z. Density and mineral content dynamics of bone tissue of the lower jaw of the rat on the background of opioid influence and after its withdrawal Wiadomości Lekarskie. 2019;LXXII(12):2300-2305
9. Seltenhammer MH, Marchart K, Paula P, Kordina N, Klupp N, Schneider B, et al. Micromorphological changes in cardiac tissue of drug-related deaths with emphasis on chronic illicit opioid abuse. Addiction. 2013;108(7):1287-1295.

10. Sullivan MD, Edlund MJ, Zhang L, Unutzer J, Wells KB. Association between mental health disorders, problem drug use, and regular prescription opioid use. Archives of internal medicine. 2006;166(19):2087-2093
11. Vestal-Laborde AA, Eschenroeder C, Bigbee JW, Robinson SE, Sato-Bigbee C. The opioid system and brain development: effects of methadone on the oligodendrocyte lineage and the early stages of myelination. Dev. Neurosci. 2014;36:409-421.
12. Brock C, Olesen SS, Olesen AE, Frokjaer JB, Andersen T, Drewes AM. Opioid-induced bowel dysfunction: pathophysiology and management. Drugs. 2012;72(14):1847-1865.
13. Mateshuk-Vatseba L, Pidvalna U, Kost A. Peculiarities of vascular tunic microstructure of the white rat eyeball under the effect of opioid. Romanian Journal of Morphology and Embryology. 2015;56(3):1057-1062.
14. Dorn S, Lembo A, Cremonini F. Opioid-induced bowel dysfunction: epidemiology, pathophysiology, diagnosis, and initial therapeutic approach. Am J Gastroenterol. 2014;2(1):31-37.
15. Pidvalna U. Compensatory– adaptive peculiarities of vascular tunic of the rat eyeball under the effect of opioid. Folia Medica Cassoviensia. 2015;70(1):26-27.
16. Pidvalna U, Bekesevych A, Zelenyak M. Opioid as a stress trigger: cerebellum and the eyeball. Abs. of Summer School on Stress: From Hans Selye's original concept to recent advances; 2015; Grenoble, France; 2015. p. 40-41.
17. Shvyrkov MB. Stages of bone regeneration and foundation of pharmacological correction of the mandible reparative osteogenesis. Stomatologiia (Mosk). 2012;91(1):9-12.
18. Gunson MJ, Arnett GW, Milam SB. Pathophysiology and pharmacologic control of osseous mandibular condylar resorption. J Oral Maxillofac Surg. 2012 Aug;70(8):1918-34. DOI: 10.1016/j.joms.2011.07.018.
19. Mateshuk-Vatseba LR, Diskovskyi IS. The influence of an opioid on the course of reparative processes. Curr.Issues Pharm.Med.Sci. 2015;28(1):46-50.
20. Onisko RM, Paltov YV, Fik VB, Vilkhova IV, Kryvko YuYa, Yakymiv NA, vynakhidnyky; L'vivs'kyy natsional'nyy medychnyy universytet imeni Danyla Halyts'koho, patentovlasnyk. Modelyuvannya fizychnoyi opioyidnoyi zalezhnosti u shchuriv. Patent Ukrainy № 76564. 2013 Sich 10. [in Ukrainian].
21. Sohuyko RR, Masna ZZ, Bilyn GV, vynakhidnyky; L'vivs'kyy natsional'nyy medychnyy universytet imeni Danyla Halyts'koho, patentovlasnyk. Sposib modelyuvannya travmy shchelepy shchura. Patent Ukrainy №118784. 2017 Ser 28. [in Ukrainian].

АНАЛІЗ ПОСТТРАВМАТИЧНОЇ ДИНАМІКИ МІНЕРАЛЬНОГО СКЛАДУ КІСТКОВОЇ ТКАНИНИ ІНТАКТНИХ ТВАРИН НА ТЛІ ТРИВАЛОГО ЗАСТОСУВАННЯ НАЛБУФІНУ ТА ПІСЛЯ ЛІКУВАННЯ ЛІНКОМІЦИНОМ

Согуйко Р. Р., Масна З. З., Рудницька Х. І., Дахно Л. О., Челпанова І. В., Фік В. Б.

Резюме. Відповідно до даних сучасної медичної літератури, кісткова тканина зазнає негативного впливу різноманітних факторів, як зовнішнього так і внутрішнього середовищ. Травма, супутні захворювання, які супроводжуються порушенням мінерального обміну, хронічні інтоксикації, тривале та неконтрольоване вживання медикаментів, особливо наркотичних анальгетиків, може призводити до порушень мінерального складу кісткової тканини та впливати на її здатність до регенерації. *Метою нашого дослідження* було встановлення динаміки мінерального складу кісткової тканини нижньої щелепи після нанесення кістково-деструктивної травми у тварин без фонової патології, на фоні тривалого застосування налбуфіну та після лікування лінкоміцином. *Об'єкт і методи дослідження.* Матеріал дослідження були 25 статевозрілих самців щурів, вагою 180-200 г та віком 3,5 місяці. Моделювання травми проводилось шляхом порушення цілісності кісткової тканини нижньої щелепи в ділянці великих кутніх зубів за допомогою бормашини. Опіоїдну залежність моделювали шляхом щоденного введення наркотичного анальгетика Налбуфіну. Метод атомно-абсорбційного спектрального аналізу (ААСА) використовували для визначення мінерального складу. *Результати.* Мінеральний склад кісткової тканини на різних етапах експерименту мав виражену динаміку в різних групах тварин, характерну для кожного з досліджуваних елементів. *Висновки.* Після застосування кістково-деструктивної травми мінеральний склад кісткової тканини протягом трьох тижнів має виражену динаміку, різну для кожного з восьми досліджуваних мінеральних елементів. Динаміка досліджуваних мінеральних елементів протягом тритижневого посттравматичного періоду у тварин без фонової патології, на тлі тривалого застосування Налбуфіну у тварин, які отримували лінкоміцин, різна.

Ключові слова: кісткова тканина, налбуфін, мінеральний склад, кістково-деструктивна травма.

ANALYSIS OF POST-TRAUMATIC DYNAMICS OF MINERAL COMPOSITION OF BONE TISSUE IN INTACT ANIMALS ON THE BACKGROUND OF THE PROLONGED NALBUFINUM USE AND AFTER LINCOMYCIN TREATMENT

Sohuyko R. R., Masna Z. Z., Rudnytska Kh. I., Dachno L. O., Chelpanova I. V., Fik V. B.

Abstract. According to the data of modern medical literature, bone tissue is negatively affected by various factors, both external and internal. Trauma, concomitant diseases accompanied by mineral metabolism disorders, chronic intoxications, long-term and uncontrolled use of medications, especially narcotic analgesics, can lead to disturbances in the mineral composition of bone tissue and affect its ability to regenerate. *The aim of our study* was to establish the dynamics of the mineral composition of the bone tissue of the lower jaw after inflicting a bone-destructive trauma to animals without background pathology, on the background of long-term use of nalbuphine and after treatment with lincomycin. *Object and research methods.* Research material: 25 sexually mature male rats, weighing 180-200 g, at the age of 3.5 months. Modeling of the injury was carried out by breaking the integrity of the bone tissue of the lower jaw in the area of molars with the help of a drill. Opioid dependence was modeled by daily administration of the narcotic analgesic Nalbuphine. The method of atomic absorption spectral analysis (AACA) was used to determine the mineral composition. *The results.* The mineral composition of bone tissue at different stages of the experiment had pronounced dynamics in different groups of animals, characteristic to each of the studied elements. *Conclusions.* After the application of a bone-destructive trauma, the mineral composition of bone tissue during three weeks has pronounced dynamics, different for each of the eight studied mineral elements. The dynamics of the studied mineral elements during the three weeks of post-traumatic period in animals without background pathology, on the background of long-term use of Nalbuphine and in animals treated with lincomycin, is different.

Key words: bone tissue, nalbuphine, mineral composition, bone-destructive trauma.

ORCID and contributionship:
Sohuyko R. R.: 0000-0001-9293-6321 [ABD]
Masna Z. Z.: 0000-0003-2057-7061 [F]
Rudnytska Kh. I.: 0000-0001-7517-1515 [D]
Dachno L. O.: 0000-0002-5513-4976 [E]
Chelpanova I. V.: 0000-0001-5215-814X [E]
Fik V. B.: 0000-0002-2284-4488 [B]

Conflict of interest:
The authors declare no conflict of interest.

Corresponding author
Rudnytska Khrystyna Ihorivna
Danylo Halytsky Lviv National Medical University
Ukraine, 79010, Lviv, 69 Pekarska str.
Tel: 0671113077
E-mail: kristinarudnytska@gmail.com

A – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article.

Received 22.03.2022
Accepted 10.09.2022

DOI 10.29254/2077-4214-2022-3-166-456-459
UDC 611.36-092.9

Shevchuk M. M.

MACRO- AND MICROSTRUCTURAL LIVER ARRANGEMENT IN WHITE RATS IN HEALTH

Danylo Halytskyi Lviv National Medical University (Lviv, Ukraine)
mykolashevchuk1973@gmail.com

Macro- and microstructural study of the liver of white rats was carried out. It was established that weight of the liver in a white mature rat weighing 180-230 g is 11-16 g, and weight of the liver in immature rats is 6-8 g. It consists of 6 lobes, externally covered with connective tissue capsule, which is tightly fused with the visceral layer of the peritoneum. On the visceral surface, there is a porta hepatis with portal vein, own hepatic artery and hepatic ducts forming the common bile duct. Rats have no gallbladder. The internal structure of the liver is formed by parenchyma and stroma. The liver parenchyma is represented by hepatic lobules, which are formed by two rows of polygonal hepatocytes. Hepatic tubules are formed by hepatocytes. Hepatocytes are polygonal in shape, they are located in tubules in two rows. Hepatocytes are heteromorphic depending on the hepatic lobe and the region and size within a specific region of the lobule. Interlobular connective tissue trabeculae are poorly developed. Interlobular blood vessels and bile ducts in portal tracts form large vascular bundles consisting of 2-3 portal vein branches, 2-3 hepatic artery branches, and 3-4 bile ducts. Central veins were located in the center of classical hepatic lobules. Endothelial layer in the walls of the central veins was solid. Endotheliocytes were homogeneous in structure, which was characteristic for these cells.

Key words: *rat, liver, hepatocyte.*

Connection of the study with planned scientific research projects. The results of these studies were obtained by the author during the research project of Danylo Halytskyi Lviv National Medical University (Department of Pathological Anatomy and Forensic Medicine) on “Study of pathomorphological features of diseases of thyroid gland, cardiovascular digestive, urinary and reproductive systems, and the perinatal period, for improving their morphological diagnosis” (state registration № 0118U000100).

Introduction. Studies of the liver in recent years indicate functional and morphological hepatic heterogeneity [1, 2]. Heterogeneity in the structure of the liver is associated with differences between the lobes of the liver and different zones of their lobules [3]. Studies suggest that morphofunctional hepatic heterogeneity is due to the fact that pathological changes and the dynamics of their spread in the liver under various pathological conditions at the initial stages have a certain characteristic localization, which, in particular, is connected with the specific nature of its structure [4, 5]. Special mention in this regard should be made of subcapsular area of the liver because it was scantily studied [6, 7], as well as due to statistically frequent cases of its involvement in the damage area during various pathological processes.

Aim of the study is to investigate and describe morphological features of the rat liver in health.

Object and research methods. Rats were kept on a standard vivarium diet with free and unrestricted access to water. All animals were kept in the conditions of the vivarium of Danylo Halytskyi Lviv National Medical University, the experiments were conducted in accordance with the provisions of the European Convention for the Protection of Vertebrate Animals Used for Experimental and