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Chronic heart failure impact on stroke index and ejection fraction during polytrauma

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Abstract: *Study of the effect of heart failure on the course of hypovolemia during polytrauma with the absence of traumatic myocardial injury. The study involved 95 patients, who were divided into 3 groups. The first Control group (C), 29 patients had no heart failure. The second group was Standard (S), 33 patients suffered from chronic heart failure and received standard therapy according to the protocol. The third group (E) of 33 patients with chronic heart failure who, in addition to standard therapy according to protocol, received Ethylmethihydroxypyridine succinate. Patients of groups S and E had equal inclusion criteria, namely the main disease leading to chronic heart failure was arterial hypertension, which had existed for more than 5 years. Three groups of patients had no traumatic myocardial injury. The stroke index (SI) during admission of group C is 24.7±4.8 ml/m², on the 3rd day 32.8±5.0 ml/m², (p <0.001), and on the 7th day - up to 39.1±6.0 ml/m², (p <0.001). SI of group S during admission was 22,9±3,7 ml/m², on the 3rd day 26,9±4,7 ml/m² (p <0,001), and on the 7th day — 34,6±5,5 ml/m² (p <0,001). SI of group E patients during admission was 23.4±2.7 ml/m², on the 3rd day 26.1±1.5 ml/m² (p < 0.01), and on the 7th - up to 36.8±2.2 ml/m² (p < 0.01). Cardiac index (CI) of group C within admission was 2,26±0,35 l/min·m², on the 3rd day - 2.73±0.37 l/min·m² (p <0,001), and by the end of the study - up to 3.08±0.40 l/min·m² (p <0,001). CI of group S during admission amounted to 1,99±0,39 l/min·m², on the 3rd day - 2,22±0,31 l/min·m² (p <0,02), on 7th — up to 2.67±0.33 l/min·m² (p <0.001). CI of group E - 2,0±0,38 l/min·m². Until the 3rd day — 2,06±0,30 l/min·m² (p> 0.4), at the 7th reached 2.97±0.32 l/min·m² (p <0,001). Ejection fraction (EF) of group C within admission amounted to 53.7±3.4%. In the future, EF has significantly increased, reaching 59.6±5.2% (p <0.001) and 63.3±6.4% by the 7th day (p <0.01). EF of group S during admission was 47,9±4.7%, on the 3rd day it increased to 52.2±5.2% (p <0.001), and on the 7th - to 56.8±6.9% (p <0.001). EF of patients group E within the admission was - 47.5±6.9%. On the 3rd day, the EF authentically increased to 52.3±5.3% (p<0.003), and on the 7th day - to 61.5±6.4% (p <0.001). The inclusion of Ethylmethylhydroxypyridine succinate (EMGPS) in the intensive care scheme of E group patients with chronic heart failure during polytrauma without acute myocardial injury gradually improves myocardial contractility activity (MCA). On the 3rd day after patient's admission, a significant impact of EMGPS on the study of mechanics and energy indicators was not observed. But from the 7th day there was an increase in SI on 6.4% (36.8±1.2 contrary 34.6±5.5 ml/m², p = 0.03), an increase in EF on 8.3% (61.5± 6.4 contrary 56.8±6.9%, p = 0.005), CI increased on 11.2% (2.94±0.32*

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contrary 2.67±0.33 l/min·m², p < 0.001). Thus, the addition of EMGPS to the intensive care scheme to patients with chronic heart failure during polytrauma without acute myocardium injury optimizes blood circulation and its energy efficiency. Ethylmethylhydroxypyridine succinate optimizes the energy efficiency of blood circulation in patients with chronic heart failure during polytrauma without acute myocardial injury.

Key words: blood volume, cardiac output, heart diseases, hypoxia, multiple trauma.

Introduction

Around the world, the cardiovascular system diseases occupy the leading first place among the mortality of the population (Giuseppe M C Rosano and others, 2021). Thus, according to Ukraine, about 68% of cases are caused by diseases of the circulatory system, due to them 52.5% of the adult population suffer and 37% of working age people do (Nazli Ozcan Yazlamaz and others, 2021). It is considered that combined injuries play an equally important role in the causes of death and disability. According to WHO, 12 million people are dying in the world (Frederich Mun and others, 2022). Moreover, in these latter days the death rate from injuries continues growing, in Ukraine at least 40,000 people die annually as a result of trauma, and 250,000 receive disability. (Zachary T Sharfman and others, 2020). In our country, a particularly important place is occupied by polysystemic injuries, which are combined with such a concomitant pathology as cardiovascular diseases. In addition, massive bleeding leads to hypovolemia, hypoxia of all tissues, especially the myocardium. (Michael R. Zemaitis, 2022). At the moment, medicine is progressively gaining momentum in the treatment of this patient's category, but still there remains an incompletely studied problem of combining traumatic injuries with concomitant cardiovascular pathology. Therefore, we consider it relevant to finalize the intensive care scheme in such patients.

Aim

Studying the effect on the body of a polytrauma combination with concomitant chronic heart failure, as well as improving the standard protocol of intensive care.

Methods

The study was performed on the clinical basis of Emergency Medicine, Anesthesiology and Intensive Care Department of the Kharkiv National Medical University - 95 patients, who were examined and treated in polytrauma department CNE «Kharkiv City Clinical Hospital of Emergency Medical Care named after Prof. O.I. Meshchaninov» of the KhCC. The study was approved by the Commission on Ethics and Bioethics of Kharkiv National Medical University and met the ethical standards of the Bioethics Committee, developed in accordance with the Helsinki Declaration of the World Association "Ethical Principles for Conducting Scientific Medical Research Involving Humans", as amended in 2013. All patients provided written informed consent to participate in the study.

The recruitment of patients was carried out from 2018 to 2021. All 95 patients were divided into three groups. The first group included 29 patients of the Control (C) group who had no chronic heart failure, aged 58.7±9.4 years, receiving standard protocol therapy. The second group included 33 patients of the Standard (S) group, who had a concomitant pathology - chronic heart failure. Which was confirmed by the level of NT-proBNP more than 125 pg/ml, aged 60,0±9,6 years. Group S patients received standard protocol therapy too. The third group included 33 patients of group (E) with concomitant chronic insufficiency, aged 62.8±8.8 years, in whose standard therapy by protocol was included Ethylmethylhydroxypyridine succinate. Patients of all groups did not have traumatic myocardial injury, which was confirmed by the level of troponin I, which was less than 0.3 ng/mg.

Inclusion criteria: patients with combined trauma, patients in two groups (S and E) had chronic heart failure, all patients had hypovolemia, the level of consciousness on the Glasgow coma scale was not lower than 14 points, all patients gave written consent. Pregnant women and children were not included in the study.

Body mass index (BMI) was calculated in the generally accepted way by Quetelet (1835) as a ratio of body weight per *kg* to the square of growth per *m*.

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The volume of the heart chambers was determined using the ULTIMA PA ultrasonic apparatus using wide-band sensors 3.5/2.7 *MHz*, S4, S8. Standard projections were used: parasternally on a long and short axis, apically - 2, 4 and 5 chamber positions.

The TnI level was determined using the biochemical automatic analyzer «Cobas Integra 400» (Germany).

The NT-proBNP level was measured by immunochromatographic method.

Blood pressure (BP) was measured in a routine way using the "Membrane Meter of BP General Use Modernized" IADM-OPMM No. 80897, heart rate - using a stopwatch, central venous pressure - direct Waldman method (1947) through a kawakatheter.

With the help of measured indicators SI, EF, CI were calculated according to generally accepted methods.

Statistical data processing was carried out using the Statistica 6.0 software package and Microsoft Excel Office 10. Hypotheses about the equality of the three groups means were tested using parametric methods Student's t-test. The measurement was considered significant at $p<0.05$. The statistical significance of differences between two quantitative indicators were determined using the Pearson correlation criterion. Differences were considered statistically significant at $p<0.01$.

Results

The stroke index (SI) of the Control group patients was mostly reduced on all research stages. During admission, it amounted to 24.7±4.8 ml/m^2, on the 3rd day - authentically increased to 32.8±5.0 ml/m^2, ($p < 0.001$), and on the 7th day - to 39.1±6.0 ml/m^2, ($p < 0.001$). The ejection fraction (EF), which most informatively reflects the contractile myocardium ability (CMA), fluctuated in wide range within admission and averaged was 53.7±3.4%. Subsequently, the EF authentically increased, reaching by the 3rd day 59.6±5.2% ($p < 0.001$) and 63.3±6.4% to the 7th ($p < 0.01$).

The indicators described above determined cardiac index (CI). During admission, it was reduced, being at the level of 2.26±0.35 *l/min*·m^2 on the 3rd day authentically increased to 2.73±0.37 *l/min·m*^{2} ($p < 0.001$), and by the end of the study — to 3.08±0.40 *l/min·m*^{2} ($p < 0.001$).

The dynamic of stroke index, cardiac index and ejection fraction is presented in Table 1.

SI within admission the Standard group (S) was significantly reduced, amounting to 22.9±3.7 *ml/m*^{2}, on the 3rd day it increased authentically to 26.9±4.7 *ml/*m^2 ($p < 0.001$), and on the 7th day - up to 34.6±5.5 *ml/m*^{2} ($p < 0.001$).

A similar dynamic was observed in relation to EF. During admission it was in group S 47.9±4.7%, on the 3rd day it increased to 52.2±5.2% ($p < 0.001$), and on the 7th - to 56.8±6.9% ($p < 0.001$).

The main kinetic indicator is CI – within admission was 1.99±0.39 *l/min·m*^{2}, on the 3rd day it was increased to 2.22±0.31 *l/min·m*^{2} ($p < 0.02$), on the 7th — to 2.67±0.33 *l/min m*^{2} ($p < 0.001$).

The dynamic of stroke index, cardiac index and ejection fraction is reflected in Table 2. The effect of CHF on the contractile ability of the myocardium during polytrauma is shown in Fig-

Table 1. Stroke index, cardiac index and ejection fraction of group K patients (M±σ)

Indicator	Research stage		
	Admission	3rd day	7th day
SI, ml/*m*^{2}	24,7±4,8	32,8±5,0 †	39,1±6,0 †‡
EF, %	53,7±3,4	59,6±5,2 †	63,3±6,4 †‡
CI, l/*min·m*^{2}	2,26±0,35	2,73±0,37 †	3,08±0,40 †‡

Here and beyond: † — $p < 0,05$ compared to the previous stage
‡ — $p < 0,05$ compared to the original level

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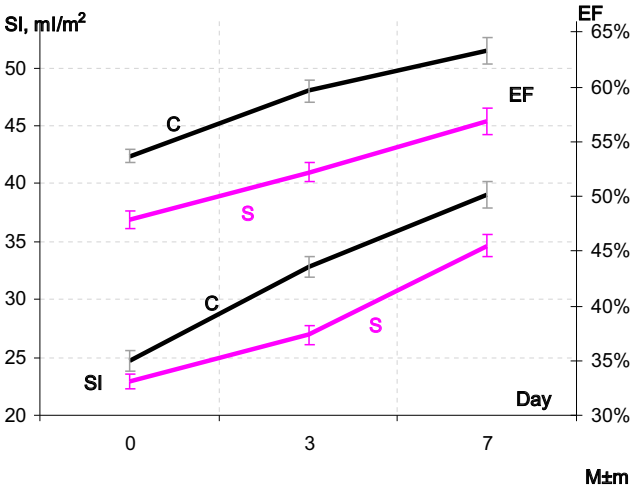

Fig. 1. The effect of CHF on the contractile ability of the myocardium during polytrauma.

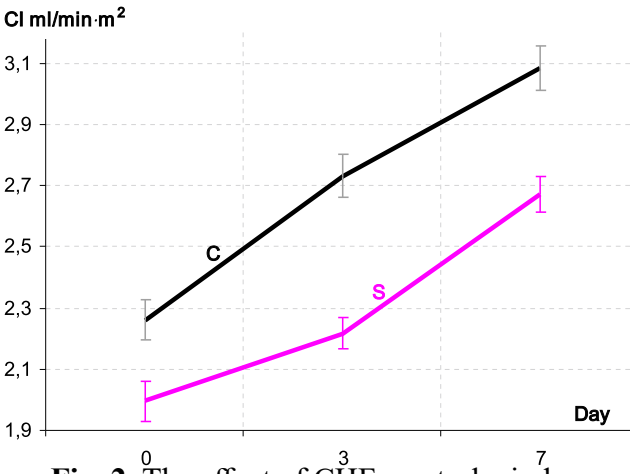

Fig. 2. The effect of CHF on stroke index, cardiac index and ejection fraction during polytrauma.

ure 1. The effect of CHF on stroke index, cardiac index and ejection fraction during polytrauma is presented in Figure 2.

SI during admission of group E patients was significantly reduced, amounting to 23.4±2.7 *ml/m*^{2}, on the 3rd day it is insignificant, but authentically, increased to 26.1±1.5 *ml/m*^{2} ($p < 0.01$), and by 7th to 36.8±2.2 *ml/m*^{2} ($p < 0.01$), only 3 patients (9.1±5.0%) had SI below 40 *ml/m*^{2}.

EF within admission of group E patients was also reduced, being at the level of 47.5±6.9%. On the 3rd day, the EF authentically increased to 52.3±5.3% ($p < 0.003$), and on the 7th day - to 61.5±6.4% ($p < 0.001$).

The integral kinetic indicator of CI during admission of group E was at a low level - 2.0±0.38 *l/min·m*^{2}. By the 3rd day, it was not significantly changed - 2.06±0.30 *l/min·m*^{2} ($p > 0.4$), but on the 7th it reached 2.97±0.32 *l/min·m*^{2} ($p < 0.001$).

Table 2. Stroke index, cardiac index and ejection fraction of group S patients (M±σ)

Indicator	Research stage		
	Admission	3rd day	7th day
SI, ml/*m*^{2}	22,9±3,7	26,9±4,7 †	34,6±5,5 †‡
EF, %	47,9±4,7	52,2±5,2 †	56,8±6,9 †‡
CI, l/*min·m*^{2}	1,99±0,39	2,22±0,31 †	2,67±0,33 †‡

Table 3. Stroke index, cardiac index and ejection fraction of E group patients (M±σ)

Indicator	Research stage		
	Admission	3rd day	7th day
SI, ml/*m*^{2}	23,4±2,7	26,1±1,5 †	36,8±2,2 †‡
EF, %	47,5±6,9	52,3±5,3 †	61,5±6,4 †‡
CI, l/*min·m*^{2}	2,00±0,38	2,06±0,30	2,97±0,32 †‡

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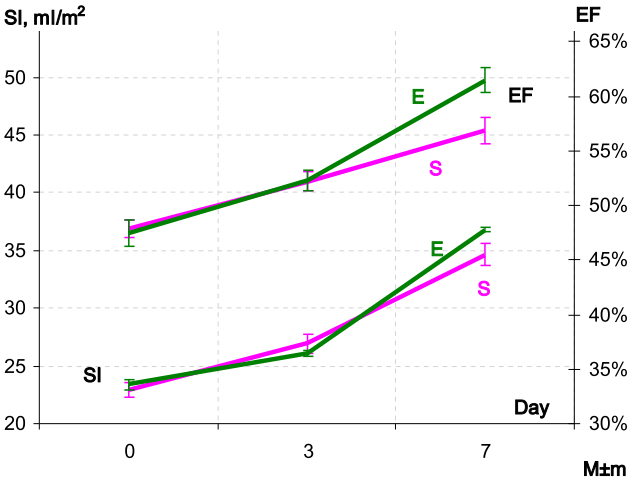

Fig. 3 The impact of EMGPS on the contractile capacity of the myocardium.

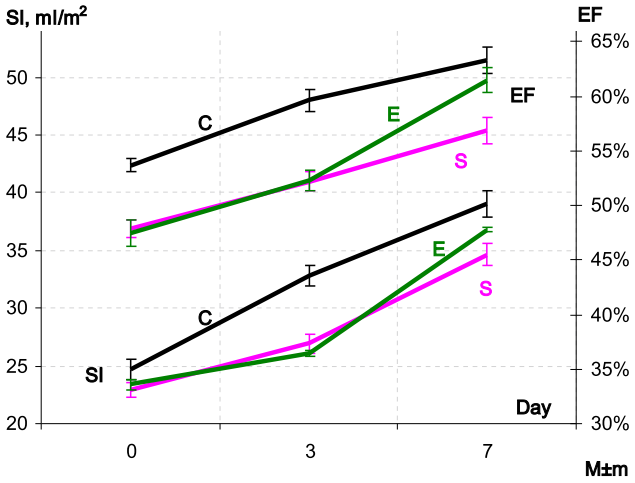

Fig. 4 Comparison of MCA indicators in the surveyed groups.

The dynamic of stroke index, cardiac index and ejection fraction is reflected in Table 3. The impact of EMGPS on the contractile capacity of the myocardium in group E patient is shown in Figure 3. Comparison of myocardial contractility ability (MCA) indicators in the surveyed groups is presented in Figure 4. The authenticity of differences between SI and EF in groups is shown in Table 4.

Discussion

The oxidative stress with activation of the apoptosis mechanisms and cell necrosis plays the leading role in myocardial injury during polytrauma in the absence of myocardial trauma (S V Kozin and others, 2021). Therefore, Ethylmethylhydroxypyridine succinate was chosen by us as a drug with antioxidant activity that reduces oxidative stress. Our results showed an authentically positive effect (EMGPS) on the myocardium. To distinguish chronic myocardial injury from acute at the present stage is not serious difficult due to the ability to control the markers level of acute myocardial disorder, one of which is troponin I (Theresea A McDonagh, 2021). In spite of the myocardium state, polytrauma leads to a general energy deficiency of the body, including the myocardium, and the myocardium loses the ability to transfer the chemical energy of the substrates into the mechanical energy of contractions at a sufficient rate (Alexander Maitz, 2021). The oxidative stress reduces the antioxidant capacity of cells, including cardiomyocytes (Pengran Liu, 2021). Knowledge of this pathogenesis process justifies the usage of antioxidant drugs, such as EMGPS for polytrauma, optimizing the metabolism of cardiomyocytes and preventing the development of irreversible processes in the myocardium (Jessica E. Tullington, 2021).

Conclusion

The presence of chronic heart failure in polytrauma without acute injury of the myocardi-

Table 4. The authenticity of differences between SI and EF in groups

Groups	Stages					
	Admission		3rd day		7th day	
	SI	EF	SI	EF	SI	EF
E/S	0,57	0,8	0,32	0,9	0,03	0,005
C/E	0,18	0,001	0,001	0,001	0,04	0,26
C/S	0,1	0,001	0,001	0,001	0,003	0,001

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um aggravates acute hypovolemia, which manifests itself primarily in a lower SI (34.6±5.5 contrary 39.1±6.0 *ml/m*^{2}, p = 0.004), lower EF (56.8±6.9 contrary 63.3±6.4%, p = 0.003), lower CI (2.67±0.33 contrary 3.08±0.40 *l/min·m*^{2}, p = 0.005). The inclusion of Ethylmethylhydroxypyridine succinate (EMGPS) in the intensive care scheme of patients with chronic heart failure during polytrauma without acute myocardial injury gradually improves MCA. On the 3rd day after patient's admission, a significant impact of EMGPS on the study of mechanics and energy indicators was not observed. But from the 7th day there was an increase in SI on 6.4% (36.8±1.2 contrary 34.6±5.5 *ml/m*^{2}, p = 0.03), an increase in EF on 8.3% (61.5± 6.4 contrary 56.8±6.9%, p = 0.005), CI increased on 11.2% (2.94±0.32 contrary 2.67±0.33 *l/min·m*^{2}, p < 0.001). Thus, the addition of EMGPS to the intensive care scheme to patients with chronic heart failure during polytrauma without acute myocardium injury optimizes blood circulation and its energy efficiency. Ethylmethylhydroxypyridine succinate optimizes the energy efficiency of blood circulation in patients with chronic heart failure during polytrauma without acute myocardial injury. This action develops slowly, during the week, but is authentically, so the inclusion of Ethylmethylhydroxyridine succinate in the intensive care scheme of this patient's category is advisable.

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Conflict of interests

All authors declare no conflicts of interests.

Consent to publication

The author has read and approved the final version of the manuscript. Author has agreed to publish this manuscript.

ORCID ID and AUTHORS CONTRIBUTION

0000-0002-0633-9801 (A, B, C, D, E, F) Lutska Svitlana

A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of article

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Вплив хронічної серцевої недостатності на ударний індекс та фракцію викиду під час політравми

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Анотація: Вивчення впливу серцевої недостатності на перебіг гіповолемії в політравмі при відсутності травматичного ураження міокарда. У дослідженні взяли участь 95 пацієнтів, які були розділені на 3 групи. Перша контрольна група (К), 29 пацієнтів не мали серцевої недостатності. Друга група була стандартною (С), 33 пацієнти страждали хронічною серцевою недостатністю і отримували стандартну терапію згідно з протоколом. Третя група (Е) з 33 пацієнтів з хронічною серцевою недостатністю, які, крім стандартної терапії по протоколу, додатково отримували Етилметигідроксипіридину сукцинат. Пацієнти в групах S і Е мали рівні критерії включення, а саме основним захворюванням, що призвело до хронічної серцевої недостатності, було артеріальна гіпертензія, яка існувала більше 5 років. У пацієнтів трьох груп травматичної травми міокарда не було. Ударний індекс (УІ) при надходженні групи К склав 24,7±4,8 мл/м^2, на 3-тю добу 32,8±5,0 мл/м^2, (р <0,001), а на 7-у добу — до 39,1±6,0 мл/м^2, (р <0,001). УІ групи С при надходженні був 22,9±3,7 мл/м^2, на 3-тю добу 26,9±4,7 мл/м^2 (р <0,001), а на 7-у добу — 34,6±5,5 мл/м^2 (р <0,001). УІ при надходженні пацієнтів групи Е складал 23,4±2,7 мл/м^2, на 3-тю добу 26,1±1,5 мл/м^2 (р <0,01), а на 7-у — до 36,8±2,2 мл/м^2 (р <0,01). Серцевий індекс (СІ) групи К при надходженні був 2,26±0,35 л/хв·м^2, на 3-тю добу - 2,73±0,37 л/хв·м^2 (р <0,001), а до кінця дослідження — до 3,08±0,40 л/хв·м^2 (р <0,001). СІ групи. С при надходженні склав 1,99±0,39 л/хв·м^2, на 3-ю добу - 2,22±0,31 л/хв·м^2 (р <0,02), на 7-у — до 2,67±0,33 л/хв·м^2 (р <0,001). Показник СІ при надходженні в групі Е — 2,0±0,38 л/хв·м^2. На 3-ю добу — 2,06±0,30 л/хв·м^2 (р> 0,4), на 7-у досяг 2,97±0,32 л/хв·м^2 (р <0,001). Фракція викиду (ФВ) групи К при надходженні склала 53,7±3,4 %. Надалі ФВ достовірно підвищувалася, досягнувши до 3-ї доби 59,6±5,2 % (р <0,001) і 63,3±6,4 % до 7-ї (р <0,01). ФВ величина при надходженні в групі С склала 47,9±4,7 %, на 3-тю добу вона зросла до 52,2±5,2 % (р <0,001), а на 7-у — до 56,8±6,9 % (р <0,001). ФВ при надходженні хворих групи Е - 47,5±6,9 %. На 3-ту добу ФВ достовірно підвищилася до 52,3±5,3 % (р <0,003), а на 7-у добу — до 61,5±6,4 % (р <0,001). Включення Етилметилгідроксипіридину сукцинату (ЕМГПС) до схеми інтенсивної терапії пацієнтів з хронічною серцевою недостатністю під час політравми без гострої травми міокарда поступово покращує скоротливу здатність міокарда (СЗМ). На 3-ю добу після надходження пацієнта значного впливу ЕМГПС на вивчення механічних та енергетичних показників

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не спостерігалося. Але з 7-ої доби спостерігалося зростання ударного індексу (УІ) на 6,4% (36,8±1,2 всупереч 34,6±5,5 *мл/м*^{2}, p = 0,03), приріст фракції викиду (ФВ) на 8,3% (61,5± 6,4 всупереч 56,8±6,9%, p = 0,005), серцевий індекс (СІ) збільшився на 11,2% (2,94±0,32 навпаки 2,67±0. 33 *л/хв·м*^{2}, p < 0,001). Таким чином, додавання ЕМГПС до схеми стандартного протоколу пацієнтам з хронічною серцевою недостатністю при політравмі без гострої травми міокарда оптимізує кровообіг і його енергоефективність. Етилметилгідроксипіридин сукцинат оптимізує енергоефективність кровообігу у пацієнтів з хронічною серцевою недостатністю під час політравми без гострої травми міокарда.

Ключові слова: гіпоксія, об›єм крові, поєднана травма, серцевий викид, хвороби серця.