

# **Circadian rhythm of oxygen saturation in the acute period of concomitant severe traumatic brain injury**

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## **Abstract**

Mechanical respiratory support (MRS) provided fluctuations in the mesor of the circadian rhythm of the oxygen saturation indicator within the normal range. The tendency to an increase in the amplitude of fluctuations in the third week of the acute period in injured people over 61 years old testified to the instability of blood oxygenation. During the acute period of CSTBI, the longest inversion — pathological migration of the peak of oxygen saturation acrophase at night (within 14 days) was found in group 3 and the smallest (4 days) in group 1.

**Keywords:** circadian rhythm of oxygen saturation, combined severe traumatic brain injury.

**Relevance.** The starting pathophysiological mechanism in acute cerebral insufficiency, as the final link, is the formation of tissue hypoxia caused by mitochondrial dysfunction. It has now been established that impaired perfusion of the brain leads to an acute deficiency of macroergs, massive release of excitatory amino acids (glutamate "excitotoxicity"), impaired permeability of cell membranes with the penetration of calcium ions into the cell, and the development of lactic acidosis in ischemic tissue. These processes are triggered even with short-term episodes of a drop in cerebral perfusion pressure, develop immediately from the moment of injury and, in general, fade away by the end of the first day of ischemia. Further damage to the nervous tissue

occurs by the mechanism of an increase in oxidative stress and local inflammation (from 2-3 hours after pathological exposure with a maximum by 12-36 hours) and the progression of apoptosis.

Combined severe traumatic brain injury (CSTBI) is always accompanied by disturbances in the function of external respiration due to impaired central regulation, as well as obstruction of the upper respiratory tract with mucus, blood, gastric contents, retraction of the root of the tongue and lower jaw, which are the reasons for the aggravation of primary brain hypoxia and the development of intracranial hypertension [1-4].

The multifaceted mechanisms of secondary brain damage (SBD) have been studied, however, there is insufficient information on the age-related characteristics of the circadian rhythm of the oxygen saturation indicator in the acute period of CSTBI.

**Purpose.** To study the circadian rhythm of oxygen saturation in the acute period of concomitant severe traumatic brain injury

**Material and research methods.** We studied the indicators of a comprehensive examination of 30 patients with concomitant severe traumatic brain injuries (CSTBI) who were admitted to the ICU of the RSCEMA neurosurgical department in the first hours after an accident - 28, catatrauma of 2 patients. Mechanical respiratory support (MRS), the duration of treatment in the ICU, the duration of hospital treatment (DHT) were studied. Continuous hourly monitoring of following indicators is presented: saturation of oxygen (SO), stroke volume of blood (SVB), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), pulse pressure (PP), cardiac output (CO), general peripheral vascular resistance (GPVR), estimation of autonomic tone (EAT), the need of myocardium in oxygen (TNMO). Mechanical Respiratory Support (MRS) was started with artificial lung ventilation (ALV) for a short time followed by a switch to SIMV. ALV was performed in the mode of normoventilation or moderate hyperventilation (pCO<sub>2</sub>– 30–35 mmHg) with an air – oxygen mixture of 30–50%. At low pO<sub>2</sub> in arterial blood, ALV was performed with constant positive pressure. However, the end-expiratory pressure did not exceed 5-7 cm aq., since higher pressure could impede the outflow of blood from the brain and increase ICP.

The assessment of the severity of the condition was carried out using scoring methods according to the scales for assessing the severity of combined injuries - the CRAMS scale, the assessment of the severity of injuries according to the ISS scale. On admission, impaired consciousness in 29 injured patients was assessed on the Glasgow Coma Scale (GS) 8 points or less. Patients were considered in three age groups: group 1 - 19-40 years old (13), group 2 - 41-60 years old (9), 3 - 61-84 years old (8 patients). Complex intensive care consisted in identifying and timely

correction of deviations: MRS, after removing from shock anesthetic, decongestant, anti-inflammatory, antibacterial, infusion therapy, correction of protein and water-electrolyte balance disorders, surgical early correction to the extent possible, stress-protective therapy.

**Results and discussion.** As shown in fig. 1, there was a strong direct correlation between the duration of MRS and the duration of intensive care in the ICU, the total duration of inpatient treatment, and only in group 3, the direct relationship between ALV and body weight was (0.6).

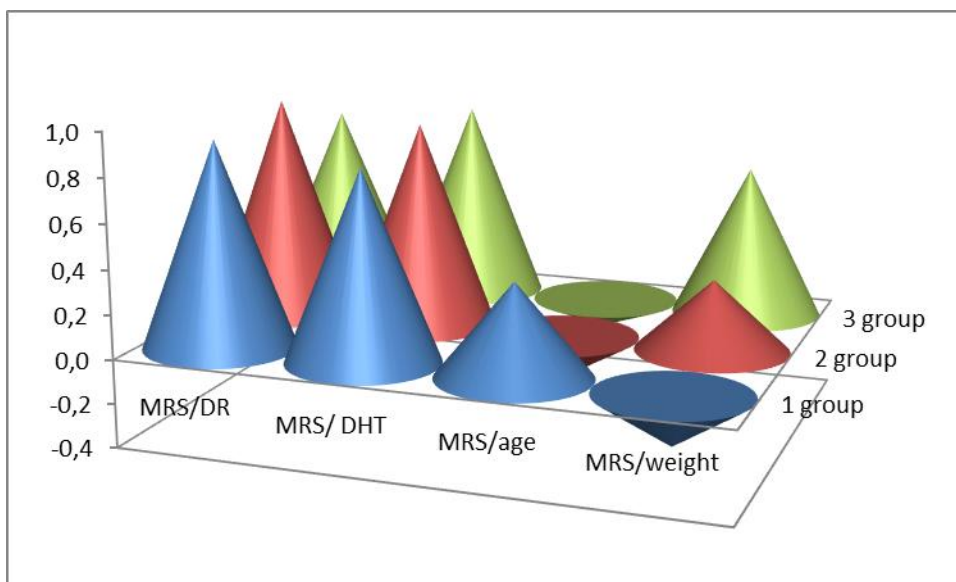


Fig. 1 Correlation links of mechanical respiratory support

Table 1.

Dynamics of the mesor of the circadian rhythm of oxygen saturation depending on age, in%

Days	Group 1	Group 2	Group 3
1	97,9±0,9	98,0±1,2	95,4±3,7
2	98,9±0,3	98,2±0,3	97,9±0,2
3	98,4±0,7	98,6±0,4	98,1±0,3
4	99,0±0,2	97,6±0,5	97,1±0,5
5	98,6±0,2	97,7±0,7	97,4±0,5
6	98,8±0,1	98,1±0,3	97,2±0,4
7	98,6±0,3	98,3±0,4	97,8±0,6
8	98,9±0,2	98,6±0,4	97,7±0,4
9	98,6±0,3	98,0±0,3	98,4±0,3
10	98,0±0,2	97,8±0,3	98,2±0,4
11	98,5±0,3	98,1±0,4	97,7±0,6
12	98,6±0,2	98,2±0,3	98,2±0,3
13	98,5±0,3	97,8±0,3	98,4±0,3
14	98,6±0,2	98,1±0,3	97,9±0,5
15	98,4±0,2	97,8±0,3	98,0±0,3
16	98,0±0,4	98,0±0,4	97,4±0,6
17	98,1±0,4	98,5±0,3	97,5±0,3
18	99,1±0,1	98,0±0,3	97,0±0,6
19	98,5±0,3	98,2±0,3	96,7±0,5

20	98,5±0,2	98,0±0,4	96,7±0,5
21	98,2±0,3	98,0±0,4	97,2±1,0
22	98,4±0,3	98,2±0,5	97,6±0,6
23	98,1±0,5	97,4±0,6	97,7±0,4
24	98,1±0,4	97,5±0,7	97,2±1,1
25	98,3±0,4	97,6±0,5	97,3±0,9

MRS was generally quite effective in maintaining the target oxygen saturation rate above 94%. There were no significant deviations from the norm and changes depending on the age of the mesor of the circadian rhythm in the oxygen saturation index in the acute period of CSTBI (tab. 1).

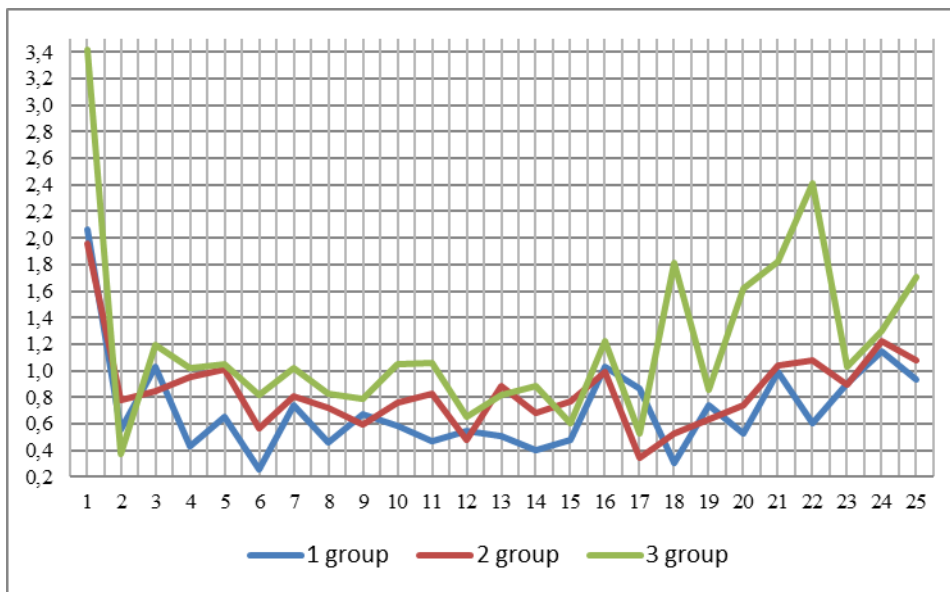


Fig. 2. Amplitude of daily fluctuations in oxygen saturation, in%

The greatest values of the amplitude of daily fluctuations of the circadian rhythm of oxygen saturation were found in group 3, which amounted to 3.4% in 1 day, 18 - 1.8%, 22 - 2.4%. Daily fluctuations in the indicator occurred within acceptable values, since oxygen saturation remained above 92%. However, the tendency to an increase in the amplitude of fluctuations in the third week of the acute period in the injured over 61 years of age testified to the instability of blood oxygenation, despite MRS (fig. 2).

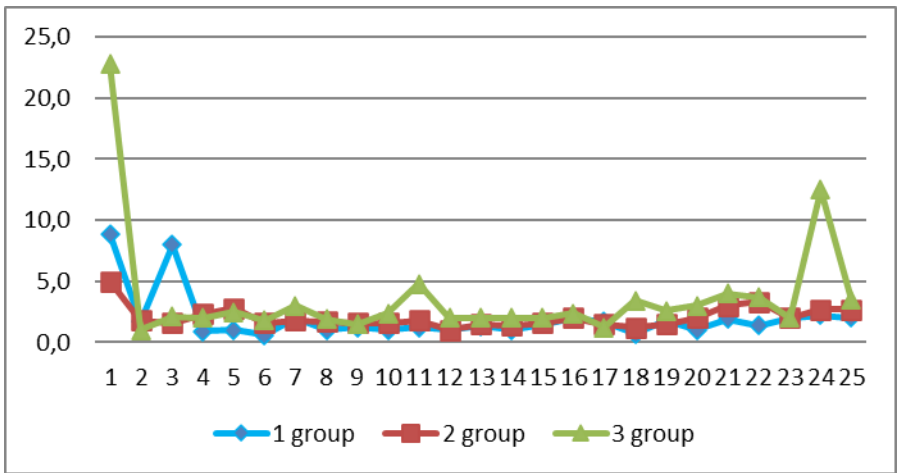


Fig. 3 The range of maximum daily oxygen saturation values

The maximum differences in the values of the oxygen saturation index were also found in patients of group 3 on day 1 - 23% and on day 24 - 12%, while in groups 1 and 2 the indicator remained stable at a level above 96% (fig. 3). Thus, the most pronounced tendency to a decrease in oxygen saturation in the blood was found in group 3.

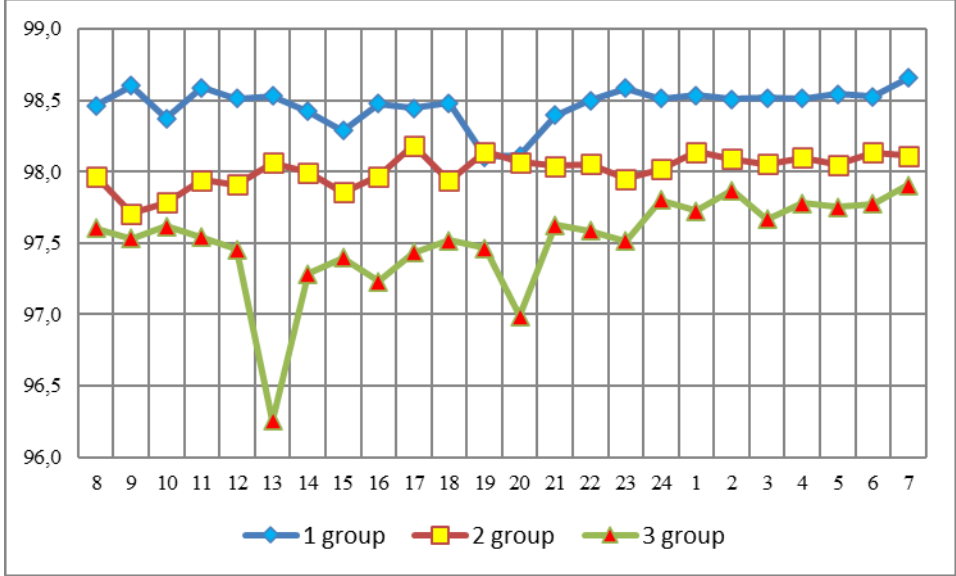


Fig. 4. Average hourly oxygen saturation data in the circadian rhythm for 25 days of the acute period of CSTBI, in%

The study of hourly values of the indicator of the circadian rhythm of oxygen saturation made it possible to designate group 3, patients, as the most unfavorable in terms of the effectiveness of MRS in the acute period of CSTBI. Fig. 4 shows that stable oxygen saturation was 98-98.5%, that is, the most effective MRS during the day and in the daytime and at night was performed in patients of groups 1 and 2. While in group 3, the tendency to decrease to 96.2% was revealed at 13 o'clock in the afternoon with a slight tendency to increase in the evening and night hours.

Probably, the tendency to a deterioration of oxygen binding at the level of the alveolar-capillary system of the lungs was due to an increase in the hydrophilicity of the pulmonary parenchyma in connection with infusion therapy, mainly performed in the morning-afternoon hours against the background of a relatively stable MRS regimen.

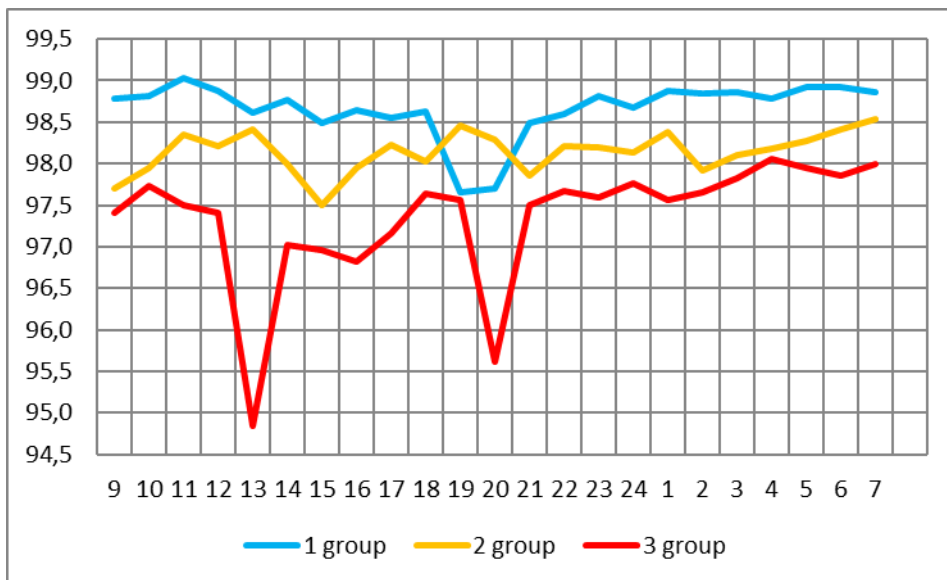


Fig. 5. Hourly dynamics of oxygen saturation in the circadian rhythm in 1-8 days in%

An attempt to identify the peculiarities of oxygen saturation depending on the time of day on the 1st - 8th day made it possible to state the most unfavorable tendency to decrease the indicator at 13 and 20 hours by 3% and 2%, respectively. While in groups 1 and 2, infusion therapy performed in the same volume did not affect the level of hemoglobin oxygenation (fig. 5).

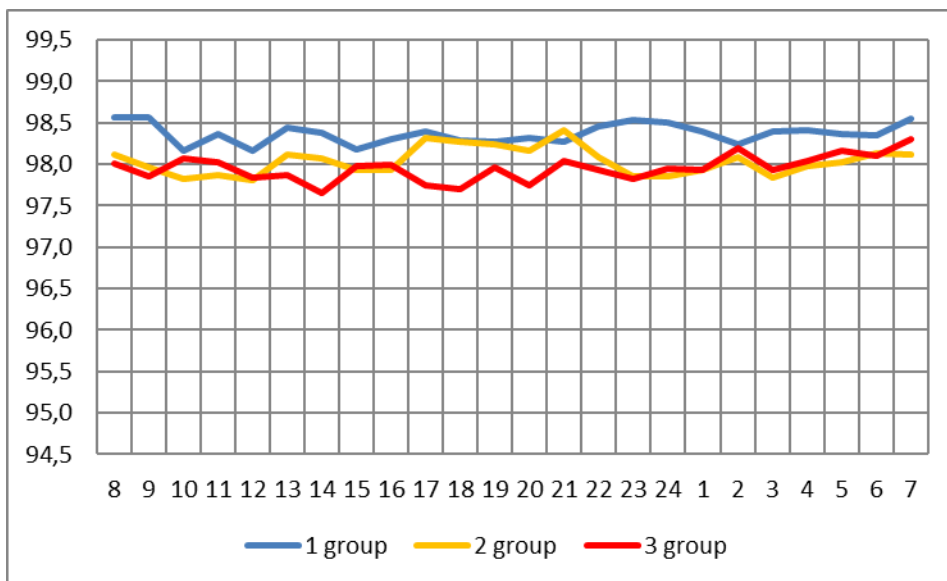


Fig. 6. Hourly dynamics of oxygen saturation in the circadian rhythm on days 9-17 in%

On the second week (9-17 days), the oxygen saturation indicator was represented by low-amplitude fluctuations in all patients at the level of 98.3% (fig. 6).

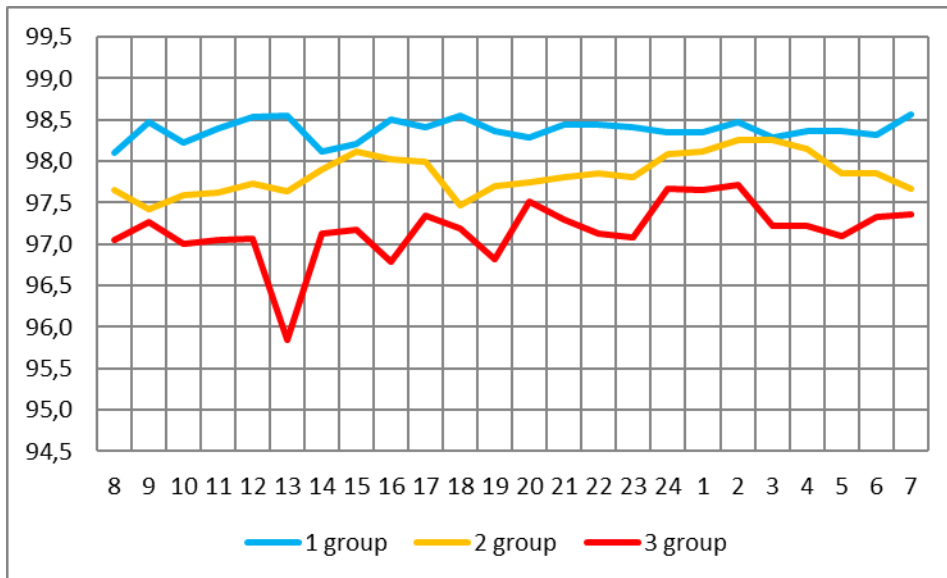


Fig. 7 Hourly dynamics of oxygen saturation in a circadian rhythm on days 17 - 25 in%.

In the third week (17-25 days), slightly lower oxygen saturation indicators were found with a decrease in oxygen saturation to 95.7% at 13 o'clock in the afternoon in group 3. In groups 1 and 2, the indicator remained stable during the light and dark hours of the day at higher values (fig. 7).

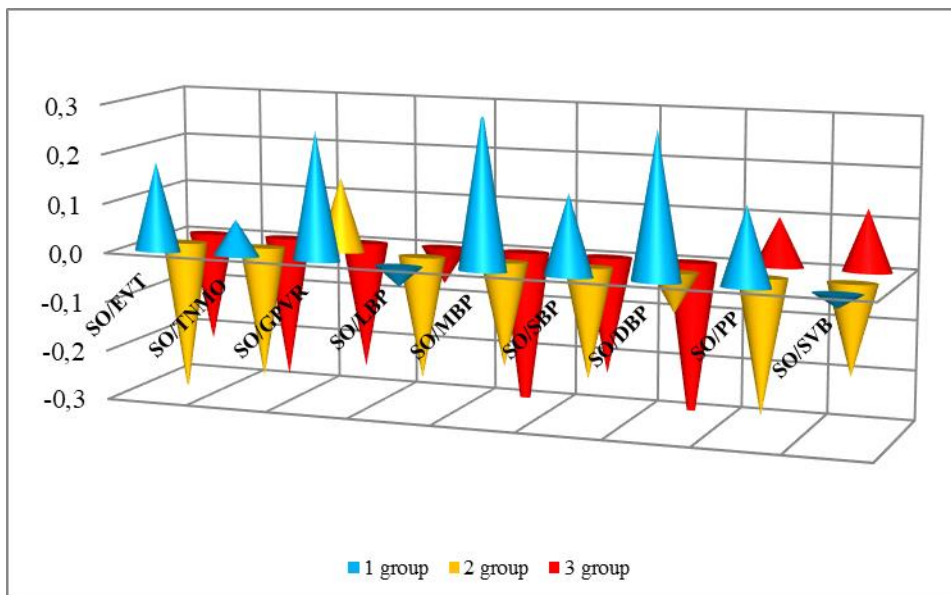


Fig. 8 Correlation of oxygen saturation with hemodynamic parameters

During the acute period of CSTBI (25 days), a direct correlation was found between the oxygen saturation index with MBP (0.26), DBP (0.26), GPVR (0.2), which reflects a certain stimulating

effect of the growth of hemoglobin oxygenation on the tone of peripheral vessels under MRS conditions (fig. 8). While in groups 2 and 3, inverse correlations of oxygen saturation CO, MBP, PP, characterize a weak tendency of the stimulating effect of a decrease in blood oxygenation on hemodynamic parameters, sympathetic activity, and an increase in myocardial oxygen demand.

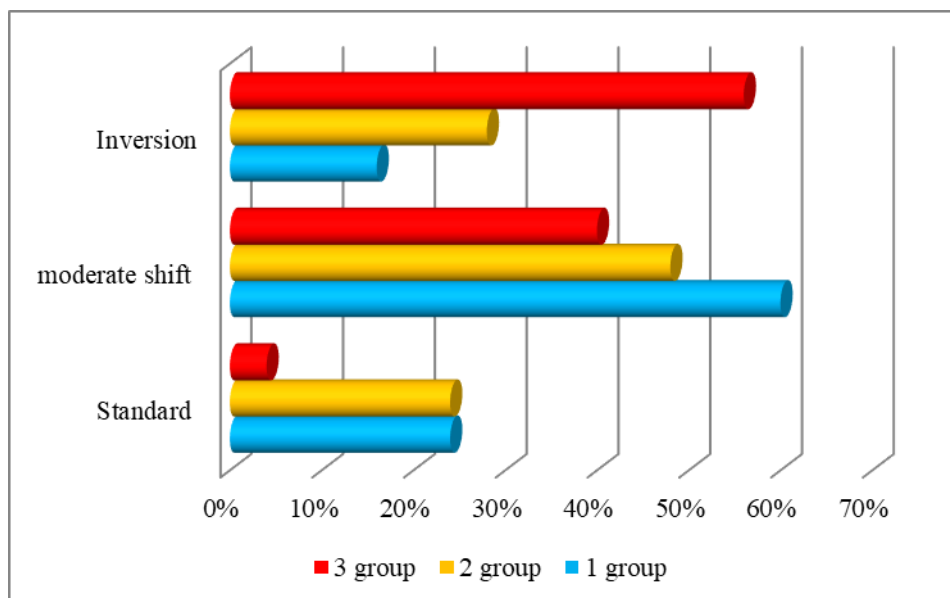


Fig. 9 The duration of the shifts of the acrophase of the circadian rhythm of oxygen saturation

During the acute period of CSTBI, the longest inversion — pathological migration of the peak of oxygen saturation acrophase at night (within 14 days) was found in group 3 and the smallest (4 days) in group 1 (fig. 9). One of the leading causes of the inversion of the circadian rhythm of the oxygen saturation index in group 3, possibly, is chronic heart failure, which significantly reduced the adaptive capabilities of the myocardium in the conditions of intensive therapy of the acute period of CSTBI.

**Conclusions.** Mechanical respiratory support (MRS) provided fluctuations in the mesor of the circadian rhythm of the oxygen saturation indicator within the normal range. The tendency to an increase in the amplitude of fluctuations in the third week of the acute period in injured people over 61 years old testified to the instability of blood oxygenation. During the acute period of CSTBI, the longest inversion — pathological migration of the peak of oxygen saturation acrophase at night (within 14 days) was found in group 3 and the smallest (4 days) in group 1.

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