ORIGINAL ARTICLES

PHOTOBIOMODULATION OF ACUTE PAIN SYNDROME AFTER SEPTOPLASTY

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Abstract

The paper evaluates the effectiveness of the use of therapeutic laser exposure (photobiomodulation therapy – PBMT) to minimize acute pain in the early postoperative period in patients after septoplasty. The study included two groups of patients. Patients of the first group (31 patients) underwent septoplasty with standard management in the postoperative period. Patients of the second group (31 patients) also underwent septoplasty, and then added PBMT to the standard measures of the postoperative period at 3, 6 and 24 h after septoplasty (λ = 0.890 µm, P = 10 W, 2 min) and then intranasally 48 h after septoplasty (λ = 0.630 µm, P = 8 W, 2 min). In patients of both groups, heart rate variability and pain were assessed using a visual analog scale within 48 hours after septoplasty. In patients of the second group, after the use of PBMT, the indicators of heart rate variability had a significantly lower total power, compared with patients of the first group. So, after PBMT, the ultra-low-frequency component of the spectral analysis of heart rate variability in the first group was 18580 ± 2067 ms^2, which is significantly higher than in the second group (8086 ± 3003 ms^2) (p <0.001). The low-frequency component of heart rate variability was also significantly higher in the first group (1871 ± 405 ms^2) compared to the second (1095 ± 190 ms^2) (p <0.005), which indicates an increase in the tension of the sympathetic part of the autonomic nervous system in the group without the use of PBMT. In the first 3 hours after surgery, the severity of pain between the groups did not differ significantly (p = 0.07). In the period from 6 to 24 hours after surgery, patients who did not undergo PBMT experienced significantly higher pain than patients with PBMT (p <0.001). Thus, in our study, the group of patients with PBMT showed better results in pain and heart rate variability compared to the classical rehabilitation of patients after septoplasty.

Key words: septoplasty, pain, photobiomodulation, heart rate variability.

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ФОТОБИОМОДУЛЯЦИЯ ОСТРОГО БОЛЕВОГО СИНДРОМА ПОСЛЕ СЕПТОПЛАСТИКИ

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Резюме

В работе оценена эффективность фотобиомодуляционной терапии (ФБМТ) для минимизации острого болевого синдрома в раннем постоперационном периоде у пациентов после проведения септопластики. В исследование были включены две группы наблюдения в количестве 31 пациент каждая. В первой группе была проведена септоплатика со стандартным ведением в послеоперационном периоде. Во второй группе к стандартным мероприятиям послеоперационного периода добавляли ФБМТ через 3, 6 и 24 ч после септопластики (λ=0,890 мкм, P=10 Вт, 2 мин) и далее интраназально через 48 ч после операции (λ=0,630 мкм, P=8 Вт, 2 мин). В обеих группах оценивали вариабельность сердечного ритма (ВСР) и болевой синдром при помощи визуально-аналоговой шкалы в течение 48 ч после септопластики. У пациентов второй группы на фоне применения ФБМТ показатели ВСР имели значимо меньшую общую мощность по сравнению с пациентами первой группы. После проведения ФБМТ ультранизкочастотный компонент спектрального анализа ВСР в первой группе составил 18580±2067 мс^2, во второй группе – 8086±3003 мс^2 (p<0,001). Низкочастотный компонент ВСР также был значимо выше в первой группе: 1871±405 мс^2 и 1095±190 мс^2 соответственно (p<0,005), что свидетельствует о повышении напряжения симпатического отдела вегетативной нервной системы в группе без применения ФБМТ. В первые 3 ч после септоплатики интенсивность боли между группами не имела достоверных различий (p=0,07). В период от 6 до 24 ч после хирургического вмешательства пациенты, которым не проводилась ФБМТ, испытывали более интенсивную боль, чем пациенты второй группы (p<0,001). Таким образом, в нашем исследовании группа пациентов с ФБМТ показала лучшие результаты по выраженности болевого синдрома и ВСР по сравнению с классической реабилитацией пациентов после септопластики.

Ключевые слова: септопластика, боль, фотобиомодуляция, вариабельность сердечного ритма.

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Introduction

Nasal septoplasty is one of the most commonly performed procedures in rhinosurgery. Frequent complications after the intervention are nasal bleeding, septal hematoma, acute rhinosinusitis, and pain syndrome [1, 2].

Septoplasty consists in the separation of the muco-supraperichondrial and/or muco-periosteal leaves and the removal of curved areas of the cartilaginous and/or bony parts of the nasal septum. As a rule, smooth sections of the extracted part of the nasal septum are placed back between the two leaves of the perichondrium. The nasal cavity is tamponed after surgery to avoid complications [3].

A special position is occupied by the issue of rehabilitation of patients after septoplasty, including high-quality anesthetic aid, analgesic therapy, and the use of topical medicines. We previously demonstrated that septoplasty as such [4], as well as with poor-quality anesthetic aid, provokes the development of the distress syndrome: an imbalance of the autonomic nervous system (ANS), a pronounced pain syndrome and a deterioration of the quality of life in the early postoperative period, which is confirmed by changes in the ANS balance and changes in HRV [5].

In order to reduce the manifestation of side effects after septoplasty, such as pain, tissue edema, inflammation, ecchymosis, photobiostimulation has recently been increasingly used [6], which improves and accelerates tissue repair, and, consequently, the healing of the surgical wound. These effects of photobiostimulation are based on improving intracellular calcium metabolism and accelerating the synthesis of ATP in mitochondria [7, 8]. Photobiomodulation therapy (PBMT) is a form of light therapy. In PBMT, light sources such as lasers or light-emitting diodes (LEDs) with a wavelength of 0.6–1 microns and a power of less than 500 MW per diode are used [9] to cause a photochemical reaction that leads to an increase in ATP synthesis in mitochondria, signal transmission in biological membranes and cells, DNA synthesis, cell proliferation, differentiation and modulation of pro-and anti-inflammatory mediators that reduce pain and inflammation [10, 11, 12]. PBMT is widely used for the treatment of various diseases: diabetic ulcers, blood diseases, musculoskeletal complications, coronary heart disease, as well as for wound healing, reducing pain and inflammation, restoring and regenerating tissues [13, 14].

It is known that after septoplasty, PBMT is used intranasally after the removal of tampons, or immediately in the case of splints [15]. At the same time, there are practically no data where the effectiveness of PBMT was evaluated with the exposure during tamponade in the first two days after septoplasty.

Taking into account the above, this study was conducted to evaluate the effectiveness of photobiomodulation (PBM) to minimize acute pain syndrome in the early postoperative period in patients after septoplasty.

Materials and methods

Rhinosurgery

Septoplasty under general anesthesia was performed in 62 patients, including 40 men and 22 women aged 18 to 44 years. The patients were randomly divided into 2 groups of 31 patients each, with an equal number of men and women. Women underwent septoplasty during the periovulatory period, since it is known that it is during this phase of the menstrual cycle that the risk of nosebleeds after rhinosurgery is minimal [16]. Immediately after the operation, all patients had an anterior nasal packing with gauze swabs in glove rubber for two days. All patients underwent septoplasty using local infiltration anesthesia with 1% procaine solution (250 mg) with 0.1% epinephrine solution (10 mg) and general anesthesia, for which Fentanyl (30 mcg/ml), Propofol (150 mg), cisatracurium besilate (nimbex) (6 mg), tranexamic acid (Tranexam) (1000 mg), atropine (0.5 mg) and metoclopramide (Cerucal) (10 mg) were used. In order to prevent the development of acute bacterial inflammation of the paranasal sinuses, oral antibacterial therapy with azithromycin was prescribed according to the scheme: 500 mg once in the morning for three days with the first administration in the morning on the day of surgery.

Photobiomodulation therapy

After 3 hours, 6 hours, and 24 hours after septoplasty, laser therapy was performed in patients of the second group. The emitter heads generated infrared pulsed laser radiation with a wavelength of 890 nm and an installed power of 10 W (LASMIK-01 device, Russia). The emitter heads were installed in the projection of the lateral cartilage and the large cartilage of the ala of nose on both sides for 2 minutes.

48 hours after the operation, patients had nasal tampons removed in both groups. In the second group, an intranasal PBMT with a nozzle was performed in a continuous, modulated mode of operation in the red optical range, with a wavelength of 630 nm and a radiation power of 8 MW. The heads were installed in both nostrils for 2 minutes (LAZMIK-01 device, Russia).

Analysis of heart rate variability and pain syndrome

To assess HRV, a daily Holter ECG monitoring was performed with MT-200 devices (Schiller, Swiss). The ECG monitoring system was put on patients 30 minutes before the septoplasty and removed 24 hours after it. HRV parameters were studied in the frequency range: low frequencies (LF, ms^2), ultra-low frequencies (ULF, ms^2), high frequencies (HF, ms^2) and total power (ms^2).

Pain syndrome was assessed with a visual analog scale (Fig. 1) in 1, 3, 6, 12, 24 and 48 hours after septoplasty, and in the second group, immediately after laser therapy sessions. Patients were asked to put a vertical line or a dot in the place on the scale that, in their opinion, corresponded to the pain they were experiencing. The scale length was 100 mm. The pain intensity was measured in mm [5].

Statistic analysis

All statistical data processing was performed with the JASP software package, version 0.14.0 (University of Amsterdam, the Netherlands) for Windows®. Continuous variables (pain value, LF, ULF, HF, Total power) were presented as the mean ± error of the mean (M±SE) and analyzed using the t–test of independent samples after checking normality with the Shapiro-Wilk test. Normally distributed data were evaluated with Student's t-test of independent samples, and abnormally distributed data were evaluated with Mann-Whitney U-test. Values of $p<0.05$ were considered statistically significant.

Results

Heart rhythm variability

After PBMT sessions, the ultra-low-frequency component of HRV spectral analysis was significantly lower in the second group (8086±3003 ms^2) than in the first (18580±2067 ms^2) ($p<0.001$) (Fig. 2a). The low-frequency HRV component was significantly higher in the first group (1871±405 ms^2) than in the second (1095±190 ms^2) ($p<0.005$), which indicates increased tension of the sympathetic part of the ANS in the group without PBMT (Fig. 2b). Based on the analysis of the high-frequency component of HRV, a decrease in the activity of the parasympathetic nervous system during the perioperative day was also recorded in the second group as a whole: 1157±220 ms^2 versus 1630±263 ms^2 in the first group ($p<0.01$) (Fig. 2c). In the second group, the total HRV power (13498±3226 ms^2) was significantly lower ($p<0.001$) than in the first (26808±2371 ms^2) (Fig. 2d).

Рис. 1. Визуально–аналоговая шкала оценки интенсивности острого болевого синдрома
Fig. 1. Visual analog scale for assessing the intensity of acute pain syndrome

The pain syndrome

In the first 3 hours after the surgical intervention, the pain intensity did not differ between the groups ($p=0.07$). In the first group, the intensity of pain increased after 6 hours compared to 3 hours after surgery, but no significant difference was found ($p=0.01$). After 6 hours, in the second group, the intensity of the pain syndrome began to decrease compared to the previous period ($p<0.05$) (Fig. 3). Further, the intensity of the pain syndrome continued to decrease in both groups, and 48 hours after the septoplasty, the patients either did not feel pain or it was very low and did not cause noticeable discomfort. At the same time, in the period from 6 to 24 hours after surgery, patients who did not undergo PBMT experienced pain that was significantly higher than in patients who underwent PBMT ($p<0.001$) (Fig. 3, table).

Discussion

It is known that the removal of tampons is advisable two days after surgery, when there is a decline in inflammatory processes and the restoration of the mucous membrane, normalization of blood supply to cartilage and bone tissues begin [1, 2], so we considered it important to use PBMT during the first two days. In the available literature, we have not found any works where PBMT was performed in patients after septoplasty with intra-nasal tampons and with a high frequency of therapy sessions on the first day after the rhinosurgical intervention.

The generally accepted theory on the mechanism of the biological effect of PBM is the absorption of light by chromophores [17]. PBMT leads to the following effects: reduction of edema and inflammation, reduction of pain, collagen synthesis, increased elasticity, increased tissue perfusion and increased tissue vascularization, increased cell proliferation, especially of fibroblasts, which generally contributes to the restoration of damaged tissues [6]. Recent studies have shown that PBMT is effective

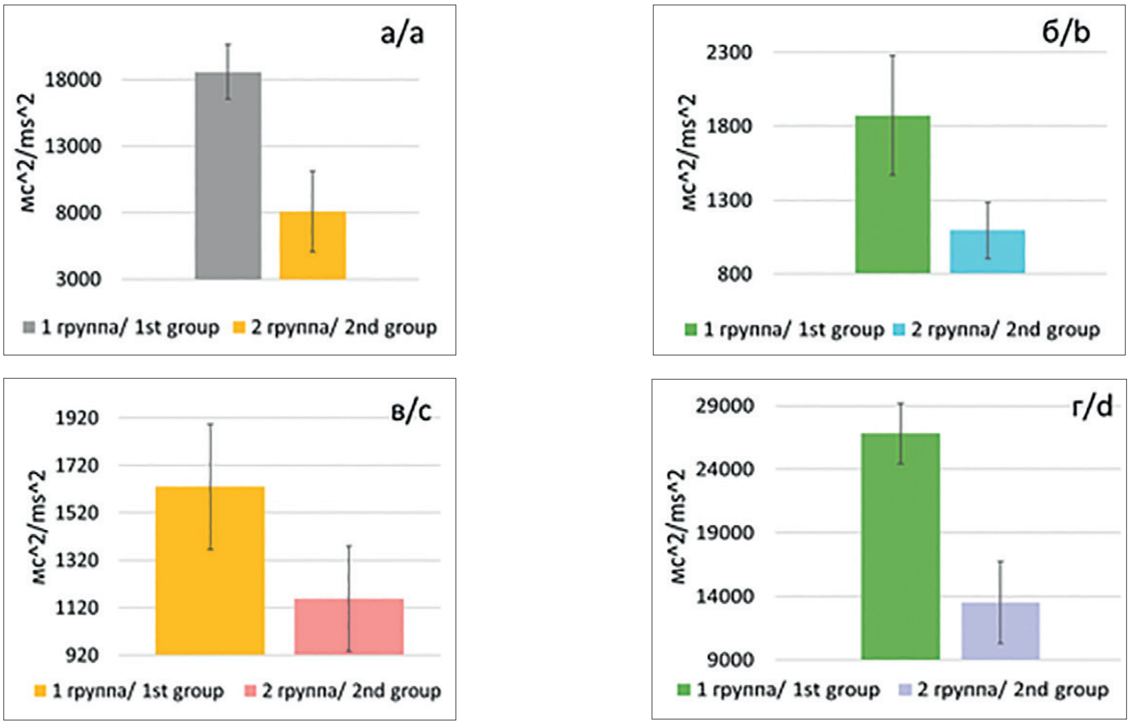

Рис. 2. Изменения показателей частотной области вариабельности сердечного ритма с применением ФБМТ после септопластики и без нее: a – ULF, b – LF, c – HF, d – общая мощность
Fig. 2. Changes in the indicators of the frequency domain of heart rate variability with the use of PBMT after septoplasty and without it: a – ULF (ultralow-frequency), b – LF (low-frequency), c – HF (high-frequency), d – Total power

Таблица
Интенсивность острого болевого синдрома после септопластики
Table
Intensity of acute pain after septoplasty

Группа Groups	Динамика интенсивности острого болевого синдрома после операции, мм Dynamics of the intensity of acute pain syndrome after surgery, mm					
	1 ч 1 h	3 ч 2 h	6 ч 6 h	12 ч 12h	24 ч 24 h	48 ч 48 h
1 группа 1st group	17,15±2,46	21,82±2,83	25±2,02	21,64±2,36	16,68±1,01	3,68±1,01
2 группа 2nd group	14,16±2,31	18,88±2,45	16,43±2,08	12,83±2,38	10,84±1,15	3,84±1,15

for various conditions: from diabetic foot to androgenic alopecia and mucositis after chemotherapy, as well as for wound healing and inflammation [7, 8, 17, 18, 19]. PBMT can play a role in reducing the number of new hemorrhages after surgical interventions in the maxillofacial region. At the same time, PBMT is positioned as a new alternative to other interventions, since it is an easy-to-use and minimally invasive method [6].

Hersant et al. evaluated the effect of a low-intensity laser on the results of graft survival in facial plastic surgery. The authors have shown that PBMT contributes to a higher survival rate of the graft and accelerates wound healing [20]. Enwemeka et al. found that PBMT is effective in promoting the restoration of damaged tissues during all three phases and reduces pain syndrome [21].

The effects of PBMT described above, especially the restoration of damaged tissue and neovascularization, provide a reduction in edema and inflammatory reactions, a decrease in the likelihood of hemorrhage [6] and, therefore, of pain in the tissue after septoplasty. With the intranasal use of laser therapy, systemic effects are also achieved through cells and blood components [22], which can probably contribute to a positive neurotherapeutic effect [23]. The tissues around the nasal

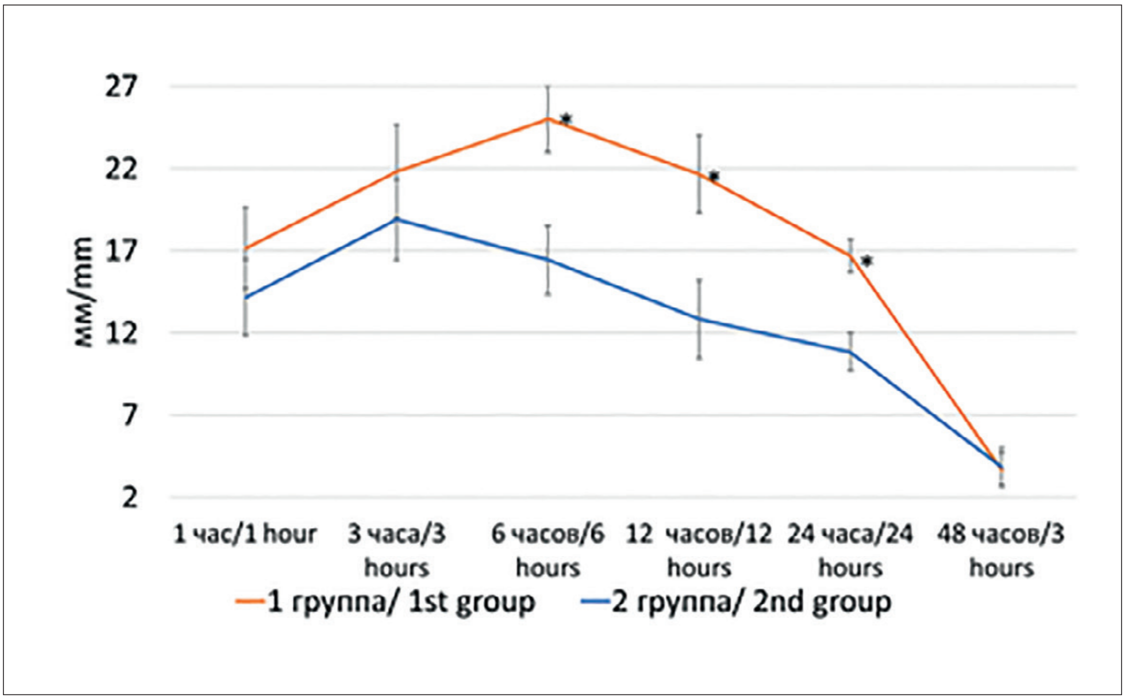

Рис. 3. Интенсивность болевого синдрома после септопластики
* – достоверные различия между группами, p=0,001
Fig. 3. Intensity of pain after septoplasty
* – significant differences between groups, p=0.001

cavity have an abundant blood supply with a relatively slow blood flow. It was shown that PBMT improves blood rheology [24], reduces its viscosity [25] and improves the blood clotting status [26] in various pathological conditions. A significantly lower intensity of pain syndrome was observed in the second group compared to patients of the first group, indicates relatively low inflammatory reactions from the blood system in the damaged area after the use of PBMT [27].

In patients who had PBMT, HRV indicators had significantly lower overall power compared to patients who did not receive laser therapy. Thus, the ultra-low frequency component, which is often associated with circadian rhythms [28], was lower in the second group. An increase in the ULF power indicates a failure of circulatory rhythms as a result of surgical traumatization against the background of inflammatory phenomena in the group which did noy have PBMT. The high-frequency (HF) component of HRV shows the tone of the parasympathetic nervous system, while the low-frequency (LF), according to a number of authors, can reflect both sympathetic (mainly) and parasympathetic tone [29]. The decrease in LF and HF after septoplasty with the use of PBMT reflects a decrease in sympathetic and parasympathetic tone after correction of nasal septum deviation. The shift of the balance of the ANS towards its sympathetic component is physiologically justified and corresponds to the degree of severity of the stress factors impact. An increase in the tone of the parasympathetic nervous system under stress may indicate the body's inadequate response [30], which may reflect the degree of surgical damage in the maxillofacial region [31]. It has been shown that after septoplasty LF HRV can sharply decrease [29]. In our study, in a group of patients with the classical variant of postoperative rehabilitation, the activity of both the sympathetic and parasympathetic parts of the ANS was increased. Studies have shown a relationship between blood rheology, cognitive functions [27] and mood improvement [32]. It was suggested that the systemic effects of PBMT after blood irradiation may also ultimately have a neuroprotective effect [23, 33, 34]. It is known that intranasal blood irradiation has the same neurological consequences as intravenous or intravascular PBMT [35]. These facts may facilitate the understanding of a lower level of pain syndrome, smaller changes in the balance of the ANS in response to surgical damage after septoplasty in patients with the use of PBM in the early postoperative period.

Conclusion

In our study, a group of patients who had PBMT showed better results when the indicators of pain syndrome and HRV were evaluated compared to the classical rehabilitation of patients after septoplasty. In our opinion, it is necessary to further develop protocols for the rehabilitation of patients after septoplasty with various types of nasal cavity tamponade.

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