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The Effect of General and Local Anesthesia on 24-Hour Profile of Cardiac Rhythm in Case of Tonsillectomy

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Abstract

Background. Disorders of endogenous rhythmicity are closely associated with the mechanisms of general adaptation syndrome, i.e., stress. Meanwhile pain, which is one of the most common causes of stress response, can induce considerable alterations in the activity of the autonomic nervous system. On the basis of the contemporary view of pain, stress and biological rhythms, we suggested that the responses of the circadian and ultradian rhythmicity of heart rate may differ depending on the type of analgesia in case of a surgical intervention.

Objectives. Specific features of the 24-hour profile of heart rate in patients who underwent tonsillectomy under different types of analgesia were studied in this work.

Subjects and methods. The study included 54 adults and was approved by the Ethic Committee of the RUDN University Institute of Medicine. The patients with chronic tonsillitis underwent tonsillectomy either under local or under general anesthesia. Control group was presented by healthy non-patient volunteers. All the participants underwent 24-hour Holter monitoring of ECG with 3-channel MT-101 Holter recorders and Software MT-200 (Schiller, Switzerland). The further processing of data was performed using software "Chronos-Fit": by linear analysis the following indices were obtained: mean daily, mean daytime, mean nighttime heart rate and circadian index; on the basis of non-linear analysis the calculated parameters were: maximum and minimum heart rate over 24 hours, range of oscillations, MESOR, amplitude and power of oscillations.

Results. In the group of patients who were operated on under general anesthesia HRmax, HRmin, MESOR and range of oscillations were significantly lower compared with the controls and with the group of local anesthesia. At the same time in the group of general anesthesia we observed a considerable increase in % rhythm (power of oscillations) in comparison with the group of local anesthesia.

Conclusion. General anesthesia has a stronger effect on the mechanisms regulating chronotropic function of the heart and more positive influence on the biorhythmological properties of heart rate compared with local anesthesia in case of tonsillectomy.

Keywords: pain, stress, heart rate, circadian rhythm, surgical intervention, anesthesia

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Introduction

In recent years there has been an increasing interest in the impact of rhythmicity changes on the pathogenesis of contemporary diseases. Disorders of the natural pattern of the oscillatory processes are closely associated with the mechanisms of general adaptation syndrome, i.e., stress [1, 2]. Meanwhile, pain, which is one of the most common causes of stress response, can induce considerable alterations in the activity of the autonomic nervous system [3, 4]. Heart rate is a rhythm-dependent function of the organism and its rhythmic profile may be very sensitive to the nociceptive excitation [5, 6].

It must be stressed that it is not enough to estimate the effects of various physiological and pathological factors on the chronotropic function of the heart only. It is important to analyze the structure of its biological rhythm. In particular some experimental studies showed that long existing genetically determined hypertension could be accompanied by no considerable deviations of HR. However, in this case, increased blood pressure becomes associated with some negative changes in the 24-hour profile of cardiac rhythm, such as a decrease in amplitude and power of oscillations [7, 8].

As pain is generally the main trigger of stress, its stimulation may lead to desynchronization of different biological rhythms of the cardio-vascular system. It was shown that pain intensity depended on the circadian rhythms which might be due to the differences in the nociceptive activity of the brain centers and nociceptive sensitivity of tissues within the 24-hour period [9].

There are several suggestions concerning possible mechanisms underlying the oscillatory character of the intensity of pain. In particular, this may be explained by a circadian pattern of the changes in the content of mediators involved in the formation of pain syndrome. It is well known that 24-hour oscillations are typical for the secretion of cerebral beta-endorphin as well as epiphyseal melatonin and cortisol [10].

The time of day when a surgical intervention is being performed is considered to be one of the factors which may have a significant effect on the rate of surgical stress and in this way can determine the course of the following post-operation pain syndrome [11]. Moreover the time of surgery may have an effect on the outcomes of intervention, as exemplified by perioperative myocardial protection due to afternoon surgery instead of morning operations in case of aortic valve replacement [12]. Experimental studies also showed a clear dependence of ventricular fibrillation probability in case of acute coronary occlusion on the time of its modeling [13]. It can be assumed that pain and stress tolerance may have temporal variations with the effect on the circadian pattern of cardiac rhythm.

On the basis of the contemporary view of pain, stress and biological rhythms we suggested that the responses of the circadian and ultradian rhythmicity of heart rate may differ depending on the type of analgesia in case of surgery.

Objectives

Specific features of the 24-hour profile of heart rate in patients who underwent tonsillectomy under different types of analgesia were studied in this work.

Subjects and Methods

Recruitment: 352 patients with the diagnosis "Chronic tonsillitis" were examined in total in the same Operation Theater during the period of recruitment within 2013 – 2015.

The study included 3 groups of patients: group 1 (n=18) – controls (healthy non-patient volunteers who matched the patients of groups 2 and 3 in sex and age); group 2 (n=18) – patients with chronic tonsillitis who underwent tonsillectomy under local infiltrative anesthesia; group 3 (n=18) – patients with chronic tonsillitis who underwent tonsillectomy under general anesthesia. The patients of groups 2 and 3 were randomly selected. The investigation was approved by the Ethic Committee of the RUDN University Institute of Medicine.

Inclusion criteria: Patients of both sex with chronic tonsillitis aged from 18 to 65 without any severe concomitant pathology.

Exclusion criteria: severe heart failure, coronary heart disease, valvular diseases, hypertension, renal failure, tuberculosis, blood disorders, disorders of

blood coagulation, diseases of the CNS, chronic alcoholism, mental diseases, diabetes mellitus.

In group 2 premedication by intramuscular administration of 1 ml 2% Solution of Trimeperidin was used. All the participants underwent 24-hour Holter monitoring of ECG; in groups 2 and 3 monitoring was started 2-3 hours before the operation. Holter monitoring of ECG was carried out using 3-channel MT-101 Holter recorders and Software MT-200 (Schiller, Switzerland). The further processing of data was performed using software "Chronos-Fit" by linear and non-linear rhythm analysis [14]. By linear analysis the following indices were obtained: mean daily, mean daytime, mean nighttime heart rate (HRd, HRdt and HRnt) and circadian index (CI) as a quotient of the daytime and nighttime values of HR. On the basis of non-linear analysis (a combination of partial Fourier analysis and stepwise regression method) the calculated parameters were as follows: maximum and minimum heart rate over 24 hours (HRmax, HRmin), range of oscillations (the difference between maximum and minimum values over 24-hour period), MESOR (the mean HR over 24 hours), amplitude (the difference between MESOR and maximum deviation during 24-hour period) and power of oscillations (percentage of HR values having oscillatory distribution within the period of its monitoring) [8]. The mean values and the error of the means were counted for all the obtained parameters. The differences between the means were evaluated using Student's *t* test. The differences were considered to be significant at $p \leq 0.05$.

Results

Characteristics of the patients of group 2 and 3 are shown in Table 1.

The results of linear rhythm analysis are represented in Table 2.

In patients who were operated on under general anesthesia, mean daily, mean daytime and mean nighttime values of HR significantly decreased in comparison with both the controls and the group in which tonsillectomy was performed using local infiltrative anesthesia.

Table 1. Mean age, body weight, BMI and blood pressure

Variable		Group 2, Local anesthesia (n = 18)	Group 3, General anesthesia (n = 18)
Age, years		43.2 ± 2.83	41.7 ± 3.23
Gender	Male, %	30	28
	Female, %	70	72
Body weight, kg		62.4 ± 2.34	63.5 ± 1.90
Body mass index, Kg/M2		21.85 ± 2.30	21.9 ± 1.70
Blood pressure, mm Hg		<129/84	<129/84

Table 2. Mean daily, daytime and nighttime heart rate (HR) and circadian index (CI) under tonsillectomy obtained by linear rhythm analysis (M ± m)

Parameter	Group 1 Controls	Group 2 Local anesthesia	Group 3 General anesthesia
HR(day), beats/min	68.57 ± 0.45	69.81 ± 2.26	66.89 ± 0.76*†
HR day time, beats/min	83.38 ± 0.56	80.81 ± 2.05	71.8 ± 0.82*†
HR night, beats/min	77.27 ± 0.32	74.12 ± 3.77*	59.3 ± 0.08*
Circadian Index	1.21 ± 0.03	1.19 ± 0.03*	1.21 ± 0.01

Note: here and in Table 3: $p \leq 0.05$ compared with *controls, †Group 2 (Local anesthesia).

In the group of general anesthesia, mild bradycardia during the nighttime period was seen. Compared with the controls, in the group of local anesthesia, mean daily and mean daytime HR were not significantly different, but mean nighttime value of HR was significantly higher.

In all three groups there were no significant differences in the levels of circadian rhythm (1.19 ± 0.03; 1.21 ± 0.01; 1.21 ± 0.03, respectively).

Examples of circadian profiles of HR in different groups are represented in Figures 1, 2 and 3.

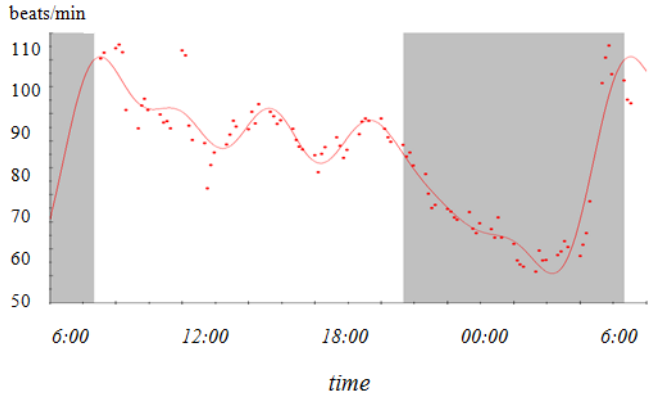

Figure 1. Circadian profile of HR in one of the healthy volunteers from the control group.

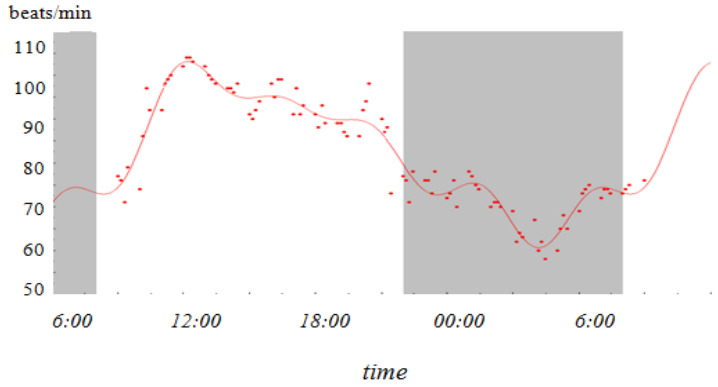

Figure 2. Circadian profile of HR in one of the patients operated on under local anesthesia.

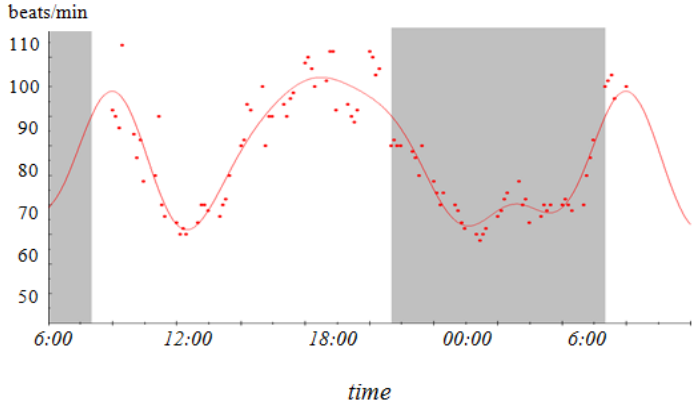

Figure 3. Circadian profile of HR in one of the patients operated on under general anesthesia.

Table 3. 24-hour values of heart rate (HR) under tonsillectomy obtained by non-linear rhythm analysis (M ± m)

Parameter	Group 1 Controls	Group 2 Local anesthesia	Group 3 General anesthesia
HRmax, beats/min	91.89 ± 1.48	99.46 ± 2.96*	85.0 ± 1.34*†
HRmin, beats/min	55.05 ± 0.74	61.91 ± 2.14*	51.37 ± 0.6*†
Range of oscillations, beats/min	36.84 ± 1.75	37.55 ± 2.29	33.63 ± 1.5*
MESOR, beats/min	77.14 ± 0.32	77.08 ± 2.07	66.76 ± 0.76*†
Amplitude, beats/min	22.09 ± 0.78	22.66 ± 1.84	18.69 ± 1.04*
Power of oscillations, %	90.4 ± 1.64	58.67 ± 2.69*	77.1 ± 2.16*†

A fuller picture of the effects of the pointed actions on the circadian dynamics of HR can only be obtained on the basis of non-linear rhythm analysis. Its results are shown in Table 3.

In the group of patients who were operated on under general anesthesia, HRmax, HRmin, MESOR and range of oscillations were significantly lower compared with the controls and with the group of local anesthesia. The pointed parameters in groups 1 and 2 had no significant differences with each other.

At the same time in the group of general anesthesia we observed a considerable increase in % rhythm (power of oscillations) in comparison with the group of local anesthesia. In the control group, % rhythm (power of oscillations) was significantly higher than in the other groups.

In the cases when tonsillectomy was performed under general anesthesia there was a tendency to bradycardia compared with the group of patients who were operated on under local anesthesia. Amplitude and range of oscillations were significantly lower than in the group of local anesthesia. In both the investigation groups, power of oscillations (% rhythm) was decreased in comparison with the group of healthy non-patient volunteers. In the group of general anesthesia this index was significantly higher compared with the group of local anesthesia. Summarizing the obtained data it can be concluded that general anesthesia is characterized by considerably smaller shifts in the adaptation mechanisms responsible for regulation of the chronotropic function of the heart provided by the autonomic nervous system.

Discussion

In our study the values of the indices reflecting rhythmic component in the 24-hour profile of HR (such as amplitude and range of oscillations) were significantly lower in the group of general anesthesia compared with the patients operated on under local anesthesia. If tonsillectomy was performed under general anesthesia the patients presented a tendency to bradycardia. Taking into consideration a pronounced stress response of the body caused by the surgical intervention and psychogenic factors the revealed features characterized by lower swings of HR during 24-hour period may contribute to a more favorable adaptation of the cardiovascular system and further general rehabilitation following surgical treatment.

Power of oscillations (% rhythm) significantly decreased in both investigation groups in comparison with the healthy non-patient volunteers. However, in the group of general anesthesia the value of this parameter was considerably higher than in the patients operated on under local anesthesia. We can suggest that under the action of general anesthesia rhythmicity of the 24-hour profile of HR is not so strongly affected as in case of local anesthesia.

In the number of studies it was repeatedly confirmed that general anesthesia was one of the important factors which could have an effect on the structure of circadian rhythms [15, 16]. It was also shown in some works that melatonin production could be changed after surgery. Moreover administration of Propofol used for intravenous anesthesia may cause a phase shift in the circadian rhythm of melatonin secretion [17, 18].

The technique of the surgical intervention may have an effect on the severity of wake-sleep cycle disorders. According to some literature data this rhythm is less influenced in case of laparoscopic operations compared with laparotomy [19].

Melatonin reduces hyperreactivity of the hypothalamus-pituitary-adrenal axis which results in less production of cortisol. Cortisol as a peripheral adaptation hormone is more actively secreted under

various pathological conditions both in adults and in children [20, 21].

The results of our study showed a significant reduction of cortisol blood levels during the early post-operative period in patients who underwent tonsillectomy under general anesthesia. This can confirm the assumption concerning the dependence of glucocorticoids levels on the action of Propofol which may be mediated by melatonin activity.

It might also be suggested that the changes of the circadian and ultradian rhythms of HR in case of tonsillectomy performed under general anesthesia may be mediated by the melatonin mechanisms which is indirectly confirmed by the mentioned above data obtained in the study with Propofol. Further investigations may be focused on the melatonin and corticoids interactions in order to reveal the links between surgical stress and disorders of biological rhythms.

Conclusion

General anesthesia has a stronger effect on the mechanisms regulating chronotropic function of the heart and more positive influence on the biorhythmological properties of heart rate compared with local anesthesia in case of tonsillectomy.

Acknowledgments

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Ethical Compliance

The authors have stated all possible conflicts of interest within this work. The authors have stated all sources of funding for this work. If this work involved human participants, informed consent was received from each individual. If this work involved human participants, it was conducted in accordance with the 1964 Declaration of Helsinki. If this work involved experiments with humans or animals, it was conducted in accordance with the related institutions' research ethics guidelines.

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