Article

Evaluation of the effectiveness of local anesthetics during septoplasty and tonsillectomy.

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Abstract: Surgical trauma provokes body's stress response with activation of inflammatory, endo-crine, metabolic, and immunological factors, which is believed to be necessary and beneficial response. Aim of the study was to compare the effectiveness of local anesthetics lidocaine and articaine in septoplasty and tonsillectomy in terms of assessing the severity of stress reactions. Patients and Methods: 125 patients with nasal septum deviation (NSD) and chronic tonsillitis (CT) were observed. Patients with NSD were divided into 2 groups: 1A – 32 patients treated by 2% lidocaine local infiltration analgesia (LIA); 1B – 30 patients treated by 2% articaine LIA. Corresponding groups of patients with CT were 2A (32 patients) and 2B (31 patients). For all patients, heart rate variability (HRV), high, low and very low frequency components were measured. Results: Estimation of group variances of HRV showed there were some disadaptation in groups 1B and 2A. High dispersion of SDANN, SDNN index and rMSSD in 1B group, SDANN values in 2A group indicate the sympathetic/parasympathetic imbalance. High frequency component were augmented in 2B group which pointed out prevailing parasympathetic tone but its high dispersion was indicative of disadaptation as well. Conclusion: Thus, with the local infiltration application of an articaine solution during septoplasty, the autonomic nervous system dystonia is observed in the early postoperative period. When anesthesia with lidocaine solution during tonsillectomy, there is also a breakdown of adaptive responses against the background of surgical stress. Based on the above data, of the presented local anesthetics, lidocaine is more effective in septoplasty, and articaine in tonsillectomy.

Keywords: septoplasty, tonsillectomy, autonomic nervous system, heart rate variability

1. Introduction

It is known that any surgical intervention entails a consistent development of stress reactions. Such interventions in otorhinolaryngology do not constitute an exception. Some of the most common are septoplasty and tonsillectomy. For example, in 50 clinics in Germany, they are leaders among surgical interventions. At the same time, between 2007 and 2010, the number of tonsillectomy in Germany almost doubled from 4,659 to 8,799 [1].

Surgical trauma provokes body's stress response with activation of inflammatory, endocrine, metabolic, and immunological factors, which is believed to be necessary and beneficial response [2]. However, an excessive increase in the production of various components of the surgical stress response can lead to hemodynamic instability, metabolic disorders, multiple organ failure, and even death [3-5]. In addition, stress includes changes in behavior, autonomic nervous system function, and increased secretion of certain hormones such as cortisol, corticosterone, and adrenal catecholamines [6]. Higher blood pressure and heart rate during stress reflect the predominance of sympathetic nervous system activity [7]. Psychological stress decreases the high-frequency component of heart rate variability (HRV) and increases the low-frequency component of HRV [8]. HRV decreases in patients with depression, manifestations of high hostility and anxiety [9]. Stress lowers the body's resistance to negative health effects [10]. The autonomic nervous system facilitates the physiological adaptation of the body in short periods, but this process can be disrupted if the synthesis of mediators such as adrenaline in the adrenal medulla is not stopped even if there is no physiological need for them.

One of the important directions in the prevention of stress-related disorders is the reduction of nociceptive sensitivity with the help of local anesthetics. Recently, local anesthetics such as lidocaine and articaine have been widely used in surgical practice. Lidocaine blocks the voltage of closed fast sodium channels in the cell membrane of postsynaptic neurons, preventing depolarization and inhibiting the formation and propagation of nerve impulses. At lower blood concentrations, lidocaine only affects sensory neurons, while at higher concentrations, its effects become more generalized.

Lidocaine also has anti-inflammatory and immunomodulatory properties. Compared to other agents in its class, lidocaine has a rapid onset of action and an intermediate duration of effect [11]. Some animal models show that lidocaine can interrupt part of the nociceptive pathway [12, 13]. Furthermore, the analgesic effect may be mediated by the effect of lidocaine on N-methyl-D-aspartate receptors. The action of articaine depends on the state of sodium channels: it has the highest affinity for open channels, an average affinity for their inactive state, and the lowest affinity when they are at rest [14]. The onset of anesthesia after the introduction of articaine with a solution of adrenaline in a ratio of 1: 100,000 occurs from 1 to 9 minutes after injection.

The onset of action of 4% articaine with 1:200,000 adrenaline occurs in 1.5–1.8 minutes with maxillary infiltration and in 1.4–3.6 minutes with blockade of the inferior alveolar nerve [15, 16]. The full effect of articaine lasts approximately 1 hour. Both concentrations give a rapid onset and severity of analgesic effect for bone (approximately 1 hour) and soft tissues (3-5 hours) [17]. It is believed that the potential efficacy of 4% articaine with 6 μg / ml of adrenaline is 2.8 times greater than that of lidocaine [18].

However, there are very few works on the comparative evaluation of lidocaine and articaine during septoplasty, and during tonsillectomy, no literature was found in the literature available to us. In this regard, the aim of the study was to compare the effectiveness of local anesthetics lidocaine and articaine in septoplasty and tonsillectomy in terms of assessing the severity of stress reactions.

2. Patients and Methods

The study included 125 people with deviated septum and chronic tonsillitis. Depending on the type of surgical intervention, the patients were divided into 2 groups: group 1 (62 patients) underwent septoplasty, group 2 (63 patients) underwent tonsillectomy. In addition, each group was divided into subgroups in which anesthesia was performed with either 2% lidocaine solution or 2% articaine solution (Table 1). The injected volume of each anesthetic did not exceed 20 ml.

Septoplasty was performed under local application and infiltration anesthesia with 2% lidocaine solution in subgroup 1A and 2% articaine solution in subgroup 1B. After the surgical intervention, the nasal cavity was tamponed on both sides with gauze swabs soaked in antibacterial ointment. Patients with chronic tonsillitis underwent bilateral tonsillectomy under local infiltration anesthesia with 2% lidocaine solution in subgroup 2A and 2% articaine solution in subgroup 2B. In septoplasty after application anesthesia, infiltration anesthesia was started from the anterior sections of the nasal septum, moving deeper, simultaneously hydroseparating the mucous membrane and perichondrium from the cartilage. Next, hydroseparation was monitored throughout the surgical field, including the nasal cavity floor and bone section on both sides. After infiltration anesthesia, an arcuate incision was made in the mucous membrane of the nasal septum in the transitional skin fold area, 1-1.5 cm away from it. The side of the incision usually corresponded to that side of the nasal cavity, where the septum was more curved. The section met the principles of "maximum sufficiency", i.e. be wide enough for cartilage manipulation. Bluntly, with the help of a raspator, the mucous membrane and perichondrium were exfoliated from the quadrangular cartilage. Next, the nasal cavity floor and the bone sections were distinguished, if they had a curvature. After the cartilage and bone sections were completely isolated on one side, they moved to the other side of the nasal septum. In a similar way, after the cut of the quadrangular cartilage, the mucous membrane and perichondrium were exfoliated, up to the bone sections. Using Killian's nasal speculum, the exposed cartilage was positioned between its jaws and the curved portion was removed using scissors or a Bellanger scalpel. It should be noted that all patients of group 1 had deformities of the nasal septum in the form of a bone ridge or spike, which were knocked off with a chisel and hammer during the operation. Next, the mucoperiosteal membranes were laid along the midline and, using a raspator, an audit was carried out for the remaining curved parts of the cartilage and bone protrusions.

Table 1. Study Design

		1 group		2 group	
		1A subgroup	1B subgroup	2A subgroup	2B subgroup
Quantity, pers.	Men	19	16	20	17
	Women	13	14	12	14
Age, years	Min	17	20	18	17
	Max	45	44	42	46
Local anesthesia		2% lidocaine solution	2% articaine solution	2% lidocaine solution	2% articaine solution

During tonsillectomy after application anesthesia, local infiltration anesthesia of the patient was performed with the indicated anesthetics in a sitting position at 5 points: above the upper pole of the tonsil, at the descent of the palatoglossal and palatopharyngeal arches, in the region of the upper pole of the tonsil, in the region of the middle pole of the tonsil, in the region the lower pole of the tonsil (at the base of the palatoglossal arch, in the projection of the 8th lower tooth), in the region of the palatopharyngeal arch of the tonsil. The needle was inserted to a depth of 1 cm, with each injection 2-3 ml of an anesthetic solution was injected. The operation was started 3-5 minutes after the end of the injections. A scalpel was used to make an incision in the mucous membrane of the anterior palatine arch on the right 0.5-0.7 cm. Then, the palatine tonsil was isolated in a blunt way. After that, the tonsil was taken on a clamp, retracted downwards, and with a sharp raspator was separated from the palatoglossal and palatopharyngeal arches, starting from the upper pole, gradually descending to the middle sections and the lower pole. When separating the tonsil, its tissue was captured with forceps along with the capsule. The tonsil on the clamp was brought down and medially, and cut off at the base with the help of Bohon's loop. At the same time, the loop was pressed against the side wall so that the entire amygdala and its lower section passed through the loop and were cut off in one block. After cutting off the tonsil, a thorough examination of the niches was carried out.

Before surgery, both groups of patients received intramuscular injections of 5 ml of a 0.5% solution of metamizole sodium and 1 ml of a 1% solution of diphenhydramine. 30 minutes before surgery, patients in both groups were placed on a 24-hour ECG Holter monitor MT-200 from Shiller. We studied SDNN (ms) - the standard deviation of all values of R-R intervals for 1 day of monitoring after surgery, as well as its night and day indicators. SDNN corresponds to the full range of all heart rate frequencies.

Normal indicators of SDNN were considered the data presented in the work of D. Nunan et al. (2010), 50±16 ms [19]. Ultra-low heart rate frequency (ULF) were measured by SDANN (ms) - this is the standard deviation of the average R-R intervals calculated over 5-minute intervals. Very low heart rate frequencies (VLF) were studied by the values of the SDNN (ms) index, which characterizes the average values of 5-minute standard deviations of R-R intervals calculated over 24 hours. In addition, we also considered the values of the high- heart rate frequency component (HF), which corresponds to the values of rMSSD (ms) - the square root of the sum of the differences in a consecutive series of R-R intervals [20, 21]. A decrease in ULF and VLF indicates the relative predominance of the action of the sympathetic nervous system, and a decrease in HF indicates a decrease in the action of the parasympathetic part of the autonomic nervous system [22,23]. The obtained values of SDNN, SDANN, SDNN index and rMSSD were compared with the reference values in accordance with the age of each patient (Table 2).

Table 2. Reference values of SDNN, SDANN, SDNN index and rMSSD

Age, years	SDNN (ms)	SDANN (ms)	SDNN Index (ms)	rMSSD (ms)

10–19	176 ± 38	159 ± 35	81 ± 20	53 ± 17
20–29	153 ± 44	137 ± 43	72 ± 22	43 ± 19
30–39	143 ± 32	130 ± 33	64 ± 15	35 ± 11a
40–49	132 ± 30	116 ± 31	60 ± 13	31 ± 11

We used the STATISTICA10.0 program for statistical processing of the results. All data are presented as means and standard deviations. The normality of data distribution in each group was assessed using the Shapiro-Wilk test. To compare normally distributed signs, an unpaired Student's t-test was used, with the distribution of at least one sign that differed from the normal one - the Mann-Whitney U-test.

3. Results

When comparing the standard deviation of R-R intervals between subgroups 1A and 1B was higher in subgroup 1A ($p<0.05$). At the same time, in patients who underwent infiltration anesthesia with articaine, a large dispersion of this indicator was observed, compared with the 1A subgroup ($p<0.05$). In the second group, there were no significant differences between both subgroups in terms of SDNN ($p<0.05$). Comparing the data of both groups, we also did not find any differences in all heart rate rates ($p<0.05$) (Fig. 1, Table 3).

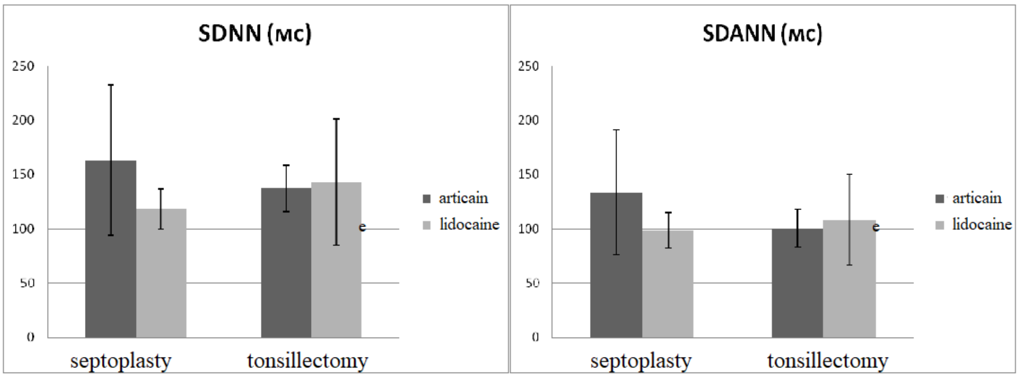

Figure 1. Standard deviation of R-R intervals and SDANN in patients undergoing septoplasty and tonsillectomy.

Table 3. Changes in heart rate variability in septoplasty and tonsillectomy. Note: * - there are significant manifestations between subgroups within the group ($p<0.05$).

subgroup	SDNN (ms)	SDANN (ms)	SDNN Index (ms)	rMSSD (ms)
1A	118±18	98±16	59±9	48±11
1B	163±49*	134±57*	89±46*	63±18*
2A	143±38	108±42	79±39	62±16
2B	137±22	100±18	87±34	49±12*

When using lidocaine in patients of group 1, SDANN was below normal values in 28.5%, in 71.5% - within the normal range. When using articaine, 37.5% of patients after septoplasty had SDANN below normal values, in the same number of patients within the age norm, and in 25% above reference values. In subgroup 2A, 45% of patients had SDANN low, 36% normal, and 18% high ($p<0.05$) (Fig. 1). A large scatter in the data of this indicator in subgroups 1B and 2A was revealed.

In subgroup 1A, all patients had SDNN index values within the normal range ($p<0.05$). When using articaine during septoplasty, it was noted that the dispersion of the SDNN index was high, in half of the patients the index values were normal, and in half they were increased ($p<0.05$). In subgroup 2A, in 72.3% of patients, the SDNN index did not go beyond the reference values, and in 36.4% it was higher than the latter ($p<0.05$). Patients who underwent tonsillectomy under local anesthesia with articaine solution did not significantly differ in SDNN index from those who used lidocaine ($p<0.05$). In group 2, a high dispersion of the SDNN index ($p<0.05$) was observed (Fig. 2).

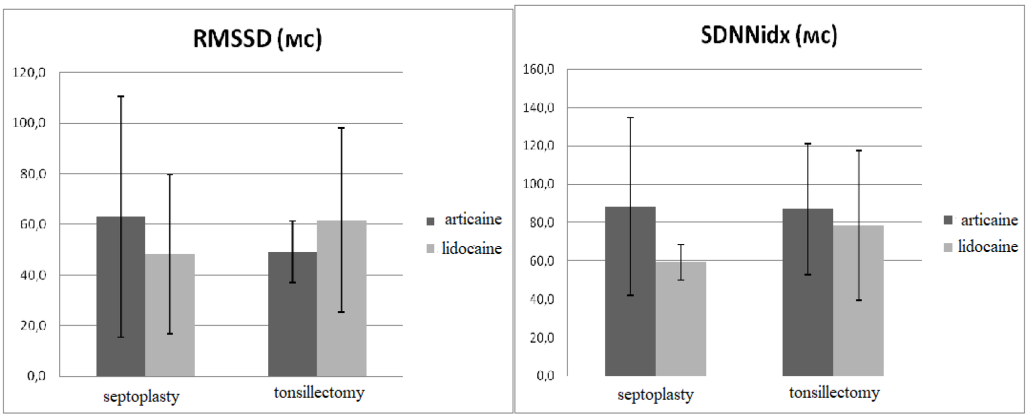

Figure 2. Comparison of SDNN index and rMSSD in patients undergoing septoplasty and tonsillectomy.

In 28.6% of patients of subgroup 1A, rMSSD was significantly higher than the age norm, and in 71.4% it was within the normal range ($p<0.05$). In subgroup 1B, rMSSD was elevated in 50%, unchanged in 25%, and below normal in 25% ($p<0.05$). In all patients of subgroup 2B, rMSSD values did not go beyond the reference values. At the same time, subgroup 2A had a high dispersion of this indicator. Thus, in 18% it was low, in 36.5% it was normal, and in 45.5% it was high ($p<0.05$) (Fig. 2).

4. Discussion

The dispersion of all heart rate frequencies showed that the disruption of adaptive responses was observed in subgroups 1B and 2A. This is evidenced by a large spread of SDANN, SDNN index and rMSSD values in subgroup 1B. This reflects the imbalance of the autonomic and sympathetic parts of the autonomic nervous system in patients of the 1B subgroup. A decrease in SDANN in patients who underwent tonsillectomy with the use of articaine solution may indicate the predominance of the sympathetic component of the ANS, however, they showed a large scatter in its values. In addition, we can not judge the obvious sympathicotonia in this subgroup and the analysis of the VLF. In contrast to ULF, the SDNN index values in most patients of the 2A subgroup were within the normal range.

The high-frequency component of the heart rate in subgroup 2B was increased in the majority, which indicates the predominance of the parasympathetic division of the autonomic nervous system, but its high variability indicates a breakdown in adaptive reactions. In our opinion, the described phenomena during septoplasty occur, most likely, due to the shorter half-life (20 min.), compared with lidocaine (90 min) [24]. In other words, during long-term septoplasty, it is necessary to use lidocaine, despite its lower anesthetic effect and greater toxicity [25-28], due to the ability to maintain its concentration in blood plasma for a longer time. In the second group, the analgesic effect of articaine was more pronounced than in the first group, due to less time spent on surgical intervention.

5. Conclusions

Thus, with the local infiltration application of an articaine solution during septoplasty, the autonomic nervous system dystonia is observed in the early postoperative period. When anesthesia with lidocaine solution during tonsillectomy, there is also a breakdown of adaptive responses against the background of surgical stress. Based on the above data, of the presented local anesthetics, lidocaine is more effective in septoplasty, and articaine in tonsillectomy.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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