Original Article

Perioperative complications of pediatric otorhinolaryngological operations

ABSTRACT

Background: The identification of risk factors for the development of perioperative complications is one of the most important problems of pediatric anesthesiology.

Purpose: To identify risk factors for the development of perioperative complications in children undergoing ambulatory surgical interventions on ENT organs.

Methods: Total of 141 patients were examined at the age from 7 to 17 years. Depending on the presence of complications all patients were divided into three groups: «No complications» (n = 64), «One complication» (n = 55) and «Two or more complications» (n = 22). The study was carried out in the following areas: Preoperative clinical status, intraoperative and postoperative complications. The severity of nasal breathing disorders was determined rhinomanometrically. 31 children underwent somnography. In the study of heart rate variability was evaluated. Intraoperative complications included: Cardiac arrhythmias, arterial hypertension and desaturation less than 90%. Postoperative complications included: Cardiorespiratory complications, pain, delirium, postoperative nausea and vomiting.

Results: The most significant complication in the intraoperative period is desaturation below 90%, in the postoperative period they are pain, nausea and vomiting. Risk factors for the development of complications in the perioperative period are a decrease in the thyromental distance, hyperplasia of the tonsils of the third degree, Malampati score ≥ to 2 points, parents' bad habits, combined neurological and respiratory pathologies in a child, an assessment of the class «allergology» of the ASPOND scale is not less than 180 points and the prevalence of vagal influences.

Conclusions: The obtained results indicate that the presence of risk factors for perioperative complications during operations on ENT organs in children are associated with the initial autonomic status and the predominance of the parasympathetic nervous system as well as with clinical markers.

Key words: Complications; ENT; heart rate variability; pediatric; perioperative

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Introduction

The development of pediatric outpatient ENT surgery is a promising direction that contributes to reducing the duration of hospitalization and improving patient comfort.[1,2] Perioperative complications increase the duration and cost of treatment, can impair the patient 's quality of life due to the possible development of adverse effects in the distant period.[3,4] However, studies on complications in ENT organ operations under general anesthesia in children are isolated. At the same time, identification of risk factors of perioperative complications is essential for their effective prevention in clinical practice. The study was aimed at identifying risk factors for the development of preoperative complications in children undergoing ambulatory surgical interventions on ENT organs.

Methods

Design of the study

The observation study was performed. Inclusion criteria: Age from a year to 17 years; surgery on ENT organs with duration of not more than 1 hour. Exclusion criteria: Acute inflammatory diseases; emotional excitement of the child not allowing the examination; emergency intervention; patients with malformations. All patients were in the teaching medical research center of the Kirgiz State Medical Academy (Bishkek) during 2017-2018.

Study description

Pre-operative clinical status, intraoperative and postoperative complications were assessed during the study. Intraoperative complications include cardiac arrhythmias, arterial hypertension and desaturation (SpO_2 less than 90%). Postoperative complications included cardiovascular complications (cardiac arrhythmias, arterial hypertension), respiratory complications (desaturation SpO_2 less than 90%, apnea), pain, delirium, postoperative nausea and vomiting.

When assessing the clinical status of a patient before surgery the presence of concomitant diseases was assessed. The pathology profile was verified using the testing program of the automated system of preventive examinations of the child – ASPE-C (http://www.medinformatika.uspb.ru/page29.html).

Analysis of heart rate variability was performed 30-90 minutes before of the operation in the supine position after 5 minutes' rest. The recording time was 2 minutes. For practical use of the assessment of vegetative status analysis of the relationship LF/HF with the vegetative index of Kerdo was carried out.

The severity of nasal respiratory disorders was also assessed the day before surgery. The criterion for nasal obstruction was a decrease in the total volume flow below 400 ml/s and an increase in the resistance of more than 0.5 Pa/ml/s.[5] The degree of tonsillar hypertrophy was evaluated according to the results of an examination.

To detect respiratory disorders during sleep, 31 children underwent somnography during night sleep for three or more hours 3-4 days before surgery. Apnea/hypopnoea index was considered to be normal less than or equal to 2, saturation more than or equal to 90.[6]

The physical condition of the patient before surgery was evaluated according to the ASA criteria.[7]

Pain was mentioned as present if the rating on the scale Hanallah was 4 or more points or the rating of one of the indicators was equal to two points. Delirium was diagnosed with a score of PAED 10 or more points.[8]

All patients were used intravenous general anesthesia with artificial lung ventilation. Premedication was carried out with atropine (0.01 mg/kg) intravenously 3 minutes before induction. Induction of anesthesia was ensured by sequential administration of propofol (2.1 mg/kg). Maintenance of anesthesia was achieved by continuous infusion of propofol (8,3 mg/kg/h) and fentanyl (4.1 mkg/kg/h). Myoplegia, if necessary, was supported by a bolus injection of suxamethonuim (1.2 mg/kg). The data sources were medical records of outpatients.

Ethical examination

The study protocol was approved by local independent ethical committee of the Saint-Petersburg State Pediatric Medical University (protocol №12/4 of 04.12.2017.)

Study groups

A total of 141 patients were examined [Table 1], all children were divided into three groups: «no complications» ($n = 64$), «one complication» ($n = 55$) and «two or more complications» ($n = 22$).

Statistical analysis

The statistical package was used Statistica 10.0 (StatSoft Inc., USA). Quantitative indicators were described using the median (25^{th}; 75^{th} percentile), qualitative ones using an absolute indicator (share in the sample 0%). For the analysis of the intergroup differences nonparametric criteria were used: Kruskall-Wallis test (ANOVA) x^2 and Fisher's exact test. To analyze the relationships between the variables the Spearman correlation coefficient was

used. For dichotomous variables the V Kramer criterion was used.

Statistically significant risk factors of perioperative sequelae have been identified with the help of logistical regressive estimate, calculating relative risk (RR) and its 95% confidence interval. Validity of multifactor mathematic models was evaluated with the help of ROC-estimate by means of calculating AUC and J-index. The differences were considered statistically significant with $P \leq 0.05$.

Results

The study of perioperative sequelae revealed that they occurred in 53.2% (75 out of 141) cases, including «one complication in one patient» - in 39% (55), «not less than two complications in one patient» - in 22 (15.6%).

The most frequent among intraoperative sequelae [Table 2] was desaturation during anesthesia induction and trachea intubation. Its frequency being statistically more significant in patients in the group «two and more complications» compared to the group «one complication» (P = 0,016). Incidence of cardio-vascular intraoperative complications was not more than 9.1% and did not have any statistically significant difference.

The most frequent postoperative complication was pain. Its incidence in the group «two and more complications» was much higher as compared to the group «one complication» (P = 0,001). The second in the rank was postoperative nausea and vomiting. The third was delirium. Statistically significant intergroup differences in nausea, vomiting and delirium incidence were not defined.

In children's groups with and without perioperation sequelae their clinical-anamnestic status was studied [Table 3]. In children of the group «two and more complications» neurological (P = 0,038) and respiratory abnormalities (P = 0,000), as well as their combination (P = 0,012), were more frequently statistically significant than in children from the group «no sequelae». Gastrointestinal diseases were also revealed in children from the group «two and more combinations», compared to the group «one complication» (P = 0,031) and the group «no combinations» (P = 0.005). Children with two and more complications had parents with bad habits much more frequently than children

Table 1: Characteristic of groups

Characteristic	Group 1 (n=64)	Group 1I (n=55)	Group 1II (n=22)
Age	8 (6; 13)	8 (4; 13)	9 (4; 10)
Male	42 (65,6%)	37 (67,3%)	13 (59,1%)
Body mass index	16,8% (15,4; 19,2)	16,2% (14,9; 18,9)	17,0% (14,5; 20,6)
Adenotomie	36 (56,3%)	33 (60%)	10 (45,5%)
Adenotonsillotomie/Adenotonsillectomie	14 (21,9%)	12 (21,8%)	9 (40,9%)
Tonsillotomie/Ttonsillectomie	3 (4,7%)	3 (5,5%)	0
Operations on perinasal sinuses, nasal partition, inner and outer ear	11 (17,2%)	7 (12,7%)	3 (13,6%)

Table 2: Structure of perioperative incidents

Complication	Total number of complications n=141	Group 1I (n=55)	Group 1II (n=20)
Perioperative incidents			
Cardiovascular complication	3 (2,1%)	1 (1,8%)	2 (9,1%)
Arrhythmia	3 (2,1%)	1 (1,8%)	2 (9,1%)
Arterial hypertension	1 (0,7%)	0	1 (4,5%)
Desaturation (SpO_2 <90%)	25 (17,7%)	14 (25,5%)	11 (50%)[a]
Postoperative incidents			
Cardiovascular complication	3 (2,1%)	1 (1,8%)	2 (9,1%)
Arrhythmia	2 (1,4%)	0	2 (9,1%)
Arterial hypertension	1 (0,7%)	1 (1,8%)	0
Respiratory complications	6 (4,3%)	4 (7,3%)	2 (9,1%)
Desaturation (SpO_2 <90%)	3 (2,1%)	2 (3,6%)	1 (4,5%)
Apnoe	4 (2,8%)	2 (3,6%)	2 (9,1%)
Pain	30 (21,8%)	16 (29,1%)	14 (63,6%)[a]
Delirium	11 (7,8%)	5 (9,1%)	6 (27,3%)
Postoperative nausea and vomiting	20 (14,2%)	12 (21,8%)	8 (36,4%)

[a]Differences are statistically significant compared to the group II (P<0,05)

Table 3: Clinical status of patients

Clinical status	Group 1 (n=66)	Group 1I (n=55)	Group 1II (n=20)
Cardiovascular diseases	7 (10,6%)	6 (10,9%)	5 (25%)
Neurologic disease	32 (48,5%)	37 (67,3%)[a]	15 (75%)[a]
Respiratory diseases	42 (63,6%)	44 (80%)[a]	18 (90%)[a]
Gastrointestinal diseases	8 (12,1%)	9 (16,4%)	8 (40%)[aб]
Other diseases	10 (15.2%)	8 (14.6%)	2 (10%)
Multiple diseases	32 (48,5%)	36 (65,5%)	18 (90%)[aб]
Cardiovascular + neurologic diseases	3 (4,6%)	4 (7,3%)	3 (15%)
Cardiovascular + respiratory diseases	7 (10,6%)	6 (10,9%)	4 (20%)
Neurologic + respiratory diseases	21 (31,8%)	30 (54,6%)[a]	14 (70%)[a]
Gastrointestinal + neurologic diseases	2 (3%)	8 (14,5%)[a]	5 (25%)[a]
Gastrointestinal + respiratory diseases	6 (6%)	6 (10,9%)	7 (35%)[aб]
Gastrointestinal + cardiovascular diseases	2 (3%)	-	1 (5%)
Allergic anamnesis	18 (27,3%)	20 (36,4%)	8 (40%)
Addictions of parents	18 (27,3%)	20 (36,4%)	14 (70%)[aб]
Mallampati classification	1 (1; 2)	1 (1; 2)	2 (2; 3)[aб]
Tiromentalny distance	7 (6; 8)	7 (6; 8)	6 (6; 8)
Score «Automated system of preventive examinations of the child population», points			
Allergic profile	155 (70; 260)	270 (140; 335)[a]	190 (125; 290)
Nutrition profile	20 (0; 70)	40 (20; 110)[a]	30 (15; 50)
Psychoneurology profile	53 (0; 150)	80 (40; 200)[a]	90 (20; 138)
Neurologic profile	145 (50; 240)	120 (70; 230)	195 (90; 385)[a]
Rhinomanometriya			
Total volume stream, ml/s	414 (246; 577)	371 (213; 583)	369 (258; 443)
Total resistance, Pa/ml/s	0,4 (0.3; 0,6)	0,4 (0,3; 0,6)	0,4 (0,3; 0,6)
Nasal obstruction	32 (48,5%)	35 (63,6%)	14 (70%)
Tonsillar hyperplasia			
No	40 (60,6%)	26 (47,3%)	9 (45%)
I-II degree	20 (30,3%)	12 (21,8%)	5 (25%)
III degree	6 (9,1%)	17 (30,9%)[a]	6 (30%)[a]
Polysomnography			
Apnoe/Hypopnoe ratio	2 (1; 3) n=12	3 (2; 3) n=12	14 (5; 29)[a,б] n=7
Maximum desaturation	90 (85; 93)	87 (84; 89)	69 (67; 91)[a]
ASA score, degree			
I degree	49 (74,2%)	43 (78%)	10 (50%)
II-III degree	17 (25,7%)	12 (22%)	10 (50%)[a,б]
Heart rate variability			
Total power (TP), ms^2	2230 (1393; 4427)	2628 (1328; 5186)	3375 (1396; 5470)
Very Low Frequency (VLF), ms^2	1024 (399; 1455)	691 (397; 1786)	1021 (454; 2064)
LOW FREQUENCY (LF), ms^2	722 (422; 1373)	677 (349; 1682)	760 (409; 1180)
The normalized indicator of low frequency	55 (49; 67)	48[a] (34; 62)	46 (28; 61)
High Frequency (HF), MC^2	552 (289; 1354)	990 (267; 2021)	877 (250; 2751)
The normalized indicator of high frequency	45 (33; 51)	52[a] (38; 66)	54 (38; 71)
Ratio low frequency/high frequency	1,2 (1; 2,1)	0,9[a] (0,5; 1,6)	0,9 (0,4; 1,6)

[a]Differences are statistically significant compared to the group I (P< 0,05); [б]differences are statistically significant compared to the group II (P<0,05)

of the group with one sequela (P = 0,010) and no sequelae (P = 0,001). The same group was characterized with higher estimate according to Mallampati score as compared to the two other groups included into the study – one complication (P < 0.05).

Higher estimate on such criteria as «allergological profile», «nutrition profile» and «psychoneurological profile» were typical for patients of the group «one complication» as compared to the group «no complications» (P = 0,008, P = 0,035 and P = 0,023, respectively).

The 3rd degree of hyperplasia of tonsils was statistically more significant in patients of the groups «two and more complications» (P = 0,018) and «one complication» (P = 0.002) as compared to the children of the «no complications» group. The ultrasound scan revealed that the average greatest level of desaturation was higher in children from the group «two

and more complications» as compared to the children from the group «no complications» ($P = 0,040$).

Defined peculiarities of clinical status of patients influenced greatly the estimate of anesthetic risk degree according to ASA. Percent of children with the second and third degree of risk was much higher in the groups «two and more sequelae» compared to the groups «one sequela» ($P = 0,010$) and «no sequelae» ($P = 0,030$).

The study of vegetative status showed higher diversity of the heart rate in children of the group "one sequela" in terms of the following indices: «normalized index of low-frequency component» ($P = 0,020$) and «normalized index of high-frequency component» ($P = 0,020$) and lower level of «proportion of low-frequency component and high-frequency component» ($P = 0,020$) compared with the group «no sequelae».

During the logistical regressive estimate, it was found out that significant risk factors of common sequelae development are the following: Thyromental distance of 5 child's fingers breadth and less, third degree hyperplasia of palatine tonsils, bad habits in parents, combined neurological and respiratory abnormality, estimate of allergological profile according to ASPE-C was 180 and more, proportion LF/HF ≤ 0.9. For the above mentioned factors of risk the formula indices of exponent of logistical regressive model were calculated:

Exp (b) =-2,5 + 0,9 * D + 0,3 * H + 0,9 * A + 1,1 * C + 1,1 * AG + 1,6 * CC

Where D – thyromental distance of 5 child's fingers breadth and less, H – hyperplasia of palatine tonsils, A - bad habits in parents, C – combination of neurological and respiratory pathology, AG - estimate of allergological profile according to ASPON-D was 180 and more, CC – proportion of low-frequency component and high-frequency component LF/HF ≤ 0.9.

Replacement of proportion LF/HF with more convenient for practical application vegetative index Kerdo did not change the informative significance of the prognostic model:

Exp (b) =-2,4 + 0,9 * D + 0,3 * H + 0,9 * A + 0,9 * C + 1,0 * AG + 1,3 * KI

Where D – thyromental distance of 5 child's fingers breadth and less, H – hyperplasia of palatine tonsils, A – bad habits in parents, C – combination of neurological and respiratory pathology, KA180 – estimate of allergological profile according to ASPON-D 180 and more, KI – vegetative index Kerdo ≤35%.

Significant risk factors of intraoperative sequelae are: Desaturation, thyromental distance of 5 child's fingers breadth and less, estimate according to Mallampati score ≥2 (MS), combination of neurological and respiratory pathology (c):

Exp (b) = -5,7 + 2,4 * D + 1,1 * MS + 1,9 * C

Where D – thyromental distance of 5 child's fingers breadth and less, MS – estimate according to Mallampati score, C – combination of neurological and respiratory pathology.

Vegetative index did not influence the incidence of intraoperative sequelae development.

Significant risk factors of postoperative sequelae were the following: Hyperplasia of palatine tonsils, bad habits in parents, gastrointestinal pathology and estimate of neurological profile according to ASPE-C 380 and more, proportion LF/HF ≤0.9. The formula of exponent of logistical regression was as follows:

Exp (b) =-2,1 + 0,3 * H + 1,1 * A + 0,5 * GIP + 1,5 *N + 1,7 * CC

Where H - hyperplasia of palatine tonsils, A – bad habits in parents, GIP – gastrointestinal pathology, N – estimate of neurological profile according to ASPON-D 380 and more, CC – proportion of spectral components LF/HF ≤ 0.9.

When LF/HF proportion was replaced with vegetative index Kerdo the prognostic model remained highly informative:

Exp (b) =-2,0 + 0,3 * H + 1,1 * A + 0,5 * GIP + 1,5 * N + 1,5 * IK

Where H – hyperplasia of palatine tonsils, A – bad habits in parents, GIP – gastrointestinal pathology, N – estimate of neurological profile according to ASPON-D 380 and more, IK – vegetative index Kerdo ≤35%.

ROC – estimate helped calculate Youden's index (J-index) and choose boundary of classification both for certain predictors [Table 4] and models given [Figure 1]. According to ROC – estimate thyromental distance, estimate according to Mallampati score, proportion of spectral components and vegetative index Kerdo, combination of respiratory and neurological pathology is most statistically significant.

The calculated optimal cutoff threshold for the prognostic models of perioperative and intraoperative sequelae including vegetative index was higher than common threshold value 0.5, which testifies to high validity of the models given.

Table 4: Range of predictive factors

Predictive factors	Range	χ^2	V Cramer	*P*	J-index	AUC ROC	*Z*-statistic
Tiromentalny distance ≤5 fingers	1	20,2	0,38	<0,001	0,52	0,78	4,5
Mallampati classification ≥2	1	16,8	0,34	<0,001	0,44	0,76	4,5
LF/HF ≤0,9	1	19,2	0,37	<0,001	0,37	0,69	4,1
Ketdo index ≥35%	1	15,1	0,33	<0,001	0,34	0,68	4
Respiratory + neurologic diseases	1	14,1	0,32	<0,001	0,41	0,71	3,8
Addictions of parents	2	10,7	0,28	0,001	0,27	0,64	2,8
Degree of tonsillar hyperplasia	2	10,6	0,27	0,01	0,22	0,60	2,1
Allergic profile ≥180 points	2	10,4	0,27	0,001	0,27	0,63	2,6
Gastrointestinal diseases	3	8,5	0,25	0,003	0,19	0,59	1,9
Neurologic profile ≥380 баллов	3	7,2	0,23	0,007	0,16	0,57	1,3

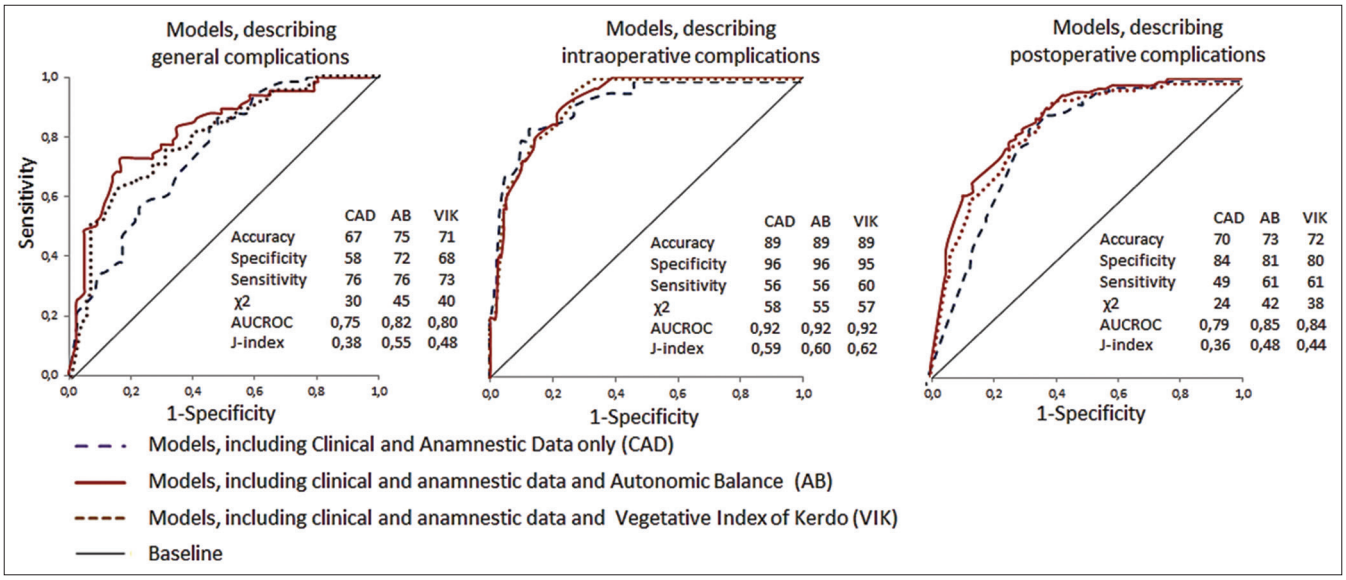

Figure 1: Features of ROC-analysis of the models of general, intra- and postoperative complications

The comparative analysis of the models of perioperative complication prediction demonstrated the absence of any differences between the model involving the connection of spectral components of heart rhythm variability and the model with Kerdo vegetative index (Kerdo VI) ($p = 0,2$). In addition, it is necessary to note that the prognostic features of that model of perioperative complications which did not take into account the vegetative pattern, were significantly lower: $p = 0,01$ and 0,049, respectively [Figure 1].

Similar results were received by the comparison of the models of postoperative complication prediction. The models considering a vegetative tone, had no differences and their parameters were significantly higher ($p = 0.01$ and 0.04, respectively) as compared to the model which did not include the information about the vegetative status [Figure 1].

The comparative evaluation of the models of intraoperative complication prediction demonstrated the absence of any differences between the models considering a vegetative tone (LF/HF and Kerdo VI), and the model which did not include the information about the vegetative status ($P > 0.3$).

Discussion

All the patients who developed two or more complications following ENT surgeries, had been performed longer surgical procedures, it was also proved by the results received with other studies.[9,10] On the basis of the received results, it was determined that the patients with many perioperative complications had higher evaluation according to the classes of «Allergology», «Psychoneurology», «Neurology» and «Nutrition profile» of automated system of prophylactic examination of children. The received pathology profiles correspond to the pathogenetic changes characteristic of chronic diseases of ENT organs, which is comparable to the results of other works.[5,11-13]

Thus, it is necessary to note that hyperplasia of palatine tonsils of the II-III degree was diagnosed in 51 (36.2%)

children, nasal obstruction - in 81 (57.5%) children, and short thyromental distance and high indicators according to Mallampati score - in 82 (58.2%) children. Just that very prevalence of children with body mass deficiency explains the absence of overweight connection with the development of complications in our study.

The predominance of parasympathetic division of vegetative nervous system is characteristic of the patients with a large number of complications, as confirmed by other researchers.[14-17] Severe hyperplasia of tonsils also increased the risk of the perioperative complications.[11,15,16]

The most significant intra-operative complication was the desaturation up to 80% (76; 86) at the moment of trachea induction and intubation that was most likely associated with the fact that hypnotics and analgetics contribute to the collapse of respiratory ways during sedation or anesthesia.[16] Respiratory complications observed in children with a short thyromental distance and higher indicators according to Mallampati score more often.

We established that the children with the diseases of ENT-organs were usually characterized by the prevalence of the influence of parasympathetic division of autonomous nervous system that could also become a cause for pain development in postoperative period. During anesthesia our patients were administered the drugs characterized by an expressed vagotonic and sympathoplegic effect, what became the priory of the maximum number of respiratory complications.[17-20] The conducted study showed that pain was a unique significant postoperative complication, which was proved by the studies of other scientists.[21-23]

Thus, the presence of risk factors of perioperative complications in case of ENT-surgeries in children that can be connected with both an initial vegetative status and prevalence of parasympathetic nervous system, and clinical and anamnestic markers.

Conclusions

1. Desaturation up to 80% at the moment of trachea induction and intubation is the most frequent and dangerous complication of anesthesia during out-patient ENT-surgeries in children. Pain and postoperative nausea and vomiting are the most frequent complications of the postoperative period
2. Vegetative dysfunction of parasympathetic type is a significant risk factor for the development of complications following general anesthesia in the postoperative period that proves the need of complete preoperative examination of the patient's vegetative status
3. The most significant risk factors for the development of complications in the perioperative period are reduction of thyromental distance (less than 5 fingers of the child crosswise), ≥2 points according to Mallampati score, mixed neurologic and respiratory pathology, ratio LF/HF≤0.9.

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Conflicts of interest
There are no conflicts of interest.

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