

Dynamics of Stress Hormone Levels with Low-Opioid Anesthesia During Thoracoplasty in Children

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Abstract The study conducted a detailed study of the quality of anesthesia when using small doses of fentanyl in combination with propofol and sevoflurane during thoracoplastic operations in children. The experiment involved 52 patients who were hospitalized with diagnoses of "funnel-shaped chest deformity 2 \ -3 st" Patients were divided into two groups: the group receiving anesthesia using fentanyl, propofol and sevoflurane; the group receiving anesthesia using fentanyl and propofol. During the study, the following parameters were analyzed: heart rate, average blood pressure, cortisol, triiodothyronine and thyroxine\levels.

Keywords Opioids, Pectus excavatum, Thoracoplasty, Fentanyl, Propofol, Sevoflurane

1. Introduction

Pectus excavatum (PE) is the most common congenital chest wall anomaly, with an incidence of 1/400 births (0.25%). Although a specific pathological mechanism has not been established, contributing factors may include disproportionate proliferation of costal cartilages, histopathological changes in the collagen content of the costal cartilages, and abnormal posterior attachment of the diaphragm to the sternum.

The defect may also be asymmetrical, often associated with rotation of the sternum and associated scoliosis. Additional factors associated with pectus excavatum include a family history of chest wall deformity and connective tissue disorders such as Marfan syndrome (up to 5% of patients). Pectus excavatum affects males four times more often than females, usually manifesting in early childhood.

The etiology remains unclear, but it appears to be polygenetic and inherited in an autosomal dominant, autosomal recessive, X-linked, or sporadic manner.

The defect is thought to result from unbalanced growth of the costochondral areas of the anterior thorax, resulting in symmetrical and asymmetrical abnormalities. Regardless of the etiology, CHD has an adverse impact on the lives of many patients. The most common symptoms include dyspnea (especially with exertion), exercise intolerance, and chest pain. Patients often experience embarrassment about their body image, which may lead to adverse psychological symptoms and decreased quality of life.

All patients with significant CHD should undergo echocardiography, especially those scheduled for surgery, as this may reveal mitral valve prolapse, compression of the

right ventricular outflow tract.

Surgical interventions performed for thoracoplasty are multi-stage and highly traumatic. At the same time, general anesthesia methods must meet the requirements of reliability, low invasiveness, create adequate conditions for the work of the operating team and ensure effective, safe pain relief [9]. From this position, opioid analgesics are widely used, which have long been the leading drugs in many surgical interventions, as the "gold standard" [6]. However, excessive use of opioids is accompanied by the development of a number of negative effects and complications [1]. Inappropriate intraoperative analgesia causes chronic pain after surgery and complications. This, in turn, affects the length of the patient's stay in the hospital and the funds spent on treatment [4,7].

Two drugs have become the mainstay of general anesthesia in recent decades: the opioid analgesic fentanyl and sevoflurane. The former has become the main component of many combined general anesthesia protocols [2], the latter, sevoflurane, is used to maintain and even induce general anesthesia [10]. But they can cause opioid-induced hyperalgesia during the post-administration phase. Numerous scientific studies have shown that the more opioid is administered during surgery, the more intense the post-operative secondary hyperalgesia [8].

These observations have prompted the development of opioid-sparing technologies; combinations of opioid and non-opioid analgesics contribute to early patient rehabilitation and reduce treatment costs. At the same time, interest in perioperative non-opioid adjuvant drugs such as dexamethasone among others has increased, with reports of beneficial analgesic and antihyperalgesic properties that have extended to the postoperative period. Preoperative administration of dexamethasone is more effective than its intraoperative

administration [3]. Dexamethasone affects the intensity of pain after surgery, reducing it, as well as the need for analgesics. The final choice of the opioid analgesic fentanyl and adequate combinations when performing general anesthesia for thoracoplasty in children is most relevant.

The aim of the work is to improve the quality of anesthesia by the combined use of small doses of the opioid fentanyl in thoracoplasty in children.

2. Materials and Methods

The study was conducted in 52 children (3-12 years old) hospitalized in the TashPMI clinic for surgical treatment for grade 2 and 3 funnel-shaped chest deformity. The objective status of the patients according to ASA corresponded to class II-III.

Criteria for inclusion in the study group:

- age from 3 to 12 years;
- informed consent of parents for surgical intervention;

Criteria for exclusion in the study group:

- age of patients under 3 years and over 12 years;
- patients with grade 4 funnel-shaped chest with respiratory failure;
- patients with keel-shaped chest deformity.

According to the plan of the conducted studies and the method of anesthesia, the patients were divided into 2 groups: Group 1 consisted of 27 (52%), who were anesthetized with fentanyl, propofol and sevoflurane; Group 2 consisted of 25 (48%), who were anesthetized with fentanyl and propofol.

- Number of patients (n);
- Average age of patients in years (Me) (%).

Table 1. Distribution of examined children by groups, gender, duration of surgery and anesthesia

Indicators	Group 1		Group 2		
	abc.	%	abc.	%	
Number of patients (n)	27	52±5,0	25	48±5,0	
Average age of patients in years (Me) (%)	6,8±0,60		6,8±0,47		
Gender:	Girls	12	44,4±7,4	11	44±6,7
	Boys	15	55,5±7,4	14	56±6,7
Duration of surgery	42,0±3,2		38,2±4,6		
Duration of anesthesia	60,8±3,1		59,7±4,9		

All patients underwent standard premedication and combined general anesthesia based on fentanyl was used for anesthetic support of the surgical intervention. Patients of the first group were administered dexamethasone 0.4% - 0.15 mg/kg 40 minutes before the operation. For induction anesthesia, propofol 2 mg/kg, fentanyl 0.005% 3-2.5 mcg/kg and arduan 0.2% - 0.06 mg/kg were successively administered intravenously. Maintenance of general anesthesia: insufflation of sevoflurane at a dose of 3 vol. % with subsequent reduction to 1.5 vol. %, fentanyl 1/2 and 1/3 of the induction dose. In the second group, induction was carried out by

administering propofol 3 mg/kg and fentanyl 5 mcg/kg, arduan 0.06 mg/kg. Maintenance of anesthesia with propofol 100-150 mcg/kg/min in the form of a constant infusion of fentanyl 1/2 and 1/3 of the induction dose. At five stages: before surgery, premedication, induction, the traumatic moment of surgery and after surgery, the heart rate (HR), mean dynamic pressure (MDP) were studied, and the levels of cortisol, triiodothyronine (T3) and thyroxine (T4) were also studied.

3. Results and Discussion

The conducted analysis of the heart rate in children of group 1 at the stages of anesthesia and surgery, at the premedication stage, its reliable increase was noted (by 12.9% of the initial), which was considered as an insignificant increase that did not provide for correction. Already at the stage of induction into anesthesia, a more significant increase was observed (by 15% of the initial). The main stage of the operation, as the most painful, was characterized by a tendency to decrease in heart rate (by 8% of the initial), while remaining within the average physiological norms. Quite distinctive was considered the final stage of anesthesia, when the heart rate was slightly reduced (by 9.1% of the initial), but in most cases did not require deepening of anesthesia.

Thus, it can be noted that the heart rate at almost all stages of surgical treatment of orthopedic pathologies in children was evenly distributed within the average physiological parameters.

Another representative in the group of hemodynamic parameters was the level of mean diastolic pressure (MDP), characterizing the total difference between systolic and diastolic arterial pressure. In patients of group 1, at the premedication stage, the MDP parameters were relatively reduced (by 1.3% from the initial value), which did not require correction. A uniform decrease in MDP at the main stage of maintaining anesthesia (by 11.4% from the initial value) did not change the general condition of patients and was considered as average physiological. Upon completion of all stages of surgical treatment and methods of anesthesia, only a slight decrease in MDP was noted relative to the previous stage. It can be noted that the changes in MDP during all stages of anesthesia did not undergo significant changes, characterizing the positively applied method of general anesthesia.

A fairly thorough study of hemodynamic parameters was also carried out in patients of group 2. Considering the obtained information on the heart rate (HR) indicators at the stages of anesthesia care, one can note a fairly pronounced difference in the fluctuations of the n indicator in the prism of comparison of a similar parameter in group 1. The premedication stage was characterized by a similar increase in the HR indicator relative to the initial values by 11.74%. The most significant changes were observed at the induction stage of anesthesia, when a special increase in HR was recorded (by 28.16% of the initial) requiring corrective

intervention with drugs, leveling the administration of anesthetics. This, in turn, made it possible to achieve a fairly striking decrease in the indicator at the main stage of anesthesia. Already at the stage of completion of the surgical intervention and methods of anesthesia, an objective increase in the heart rate level was recorded, slightly increased by 4.86% from the original. It should be noted that this type of anesthesia requires a special approach and alertness during orthopedic surgeries, regulation of the hemodynamic capabilities of the body.

The level of MDP in group 1 of patients was slightly lower

than in group 2, but the variations of changes at the stages of anesthesia were relatively uniform than in patients of group 2.

The considered parameter of heart rate in patients in group 2 was significantly higher than in patients in group 1 (by 10.87%), with a certain decrease at the main stage (16.91%), to 18.54% at the final one. This is a fairly distinctive feature of the proposed scheme of anesthesia of patients during orthopedic surgeries. When considering the cortisol levels in a comparative aspect between the two groups, we can note higher values in patients of the 2nd group (Fig. 2).

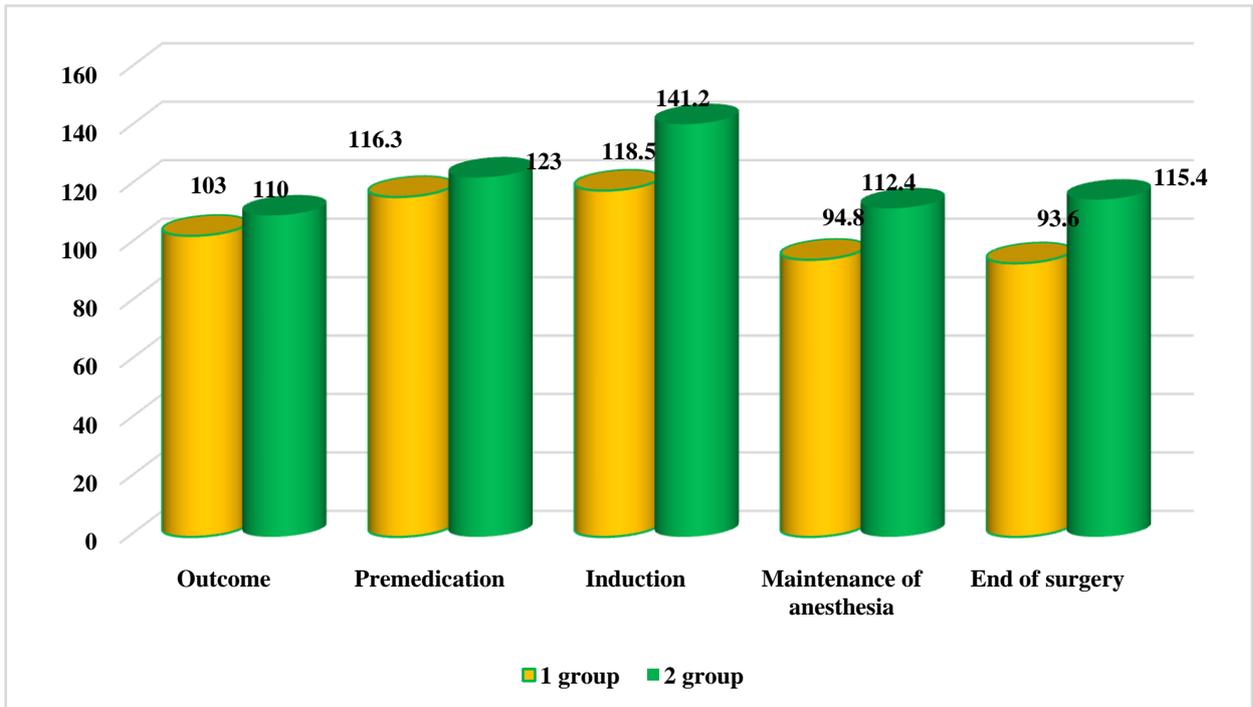


Figure 1. Dynamics of heart rate parameters at different stages of the study

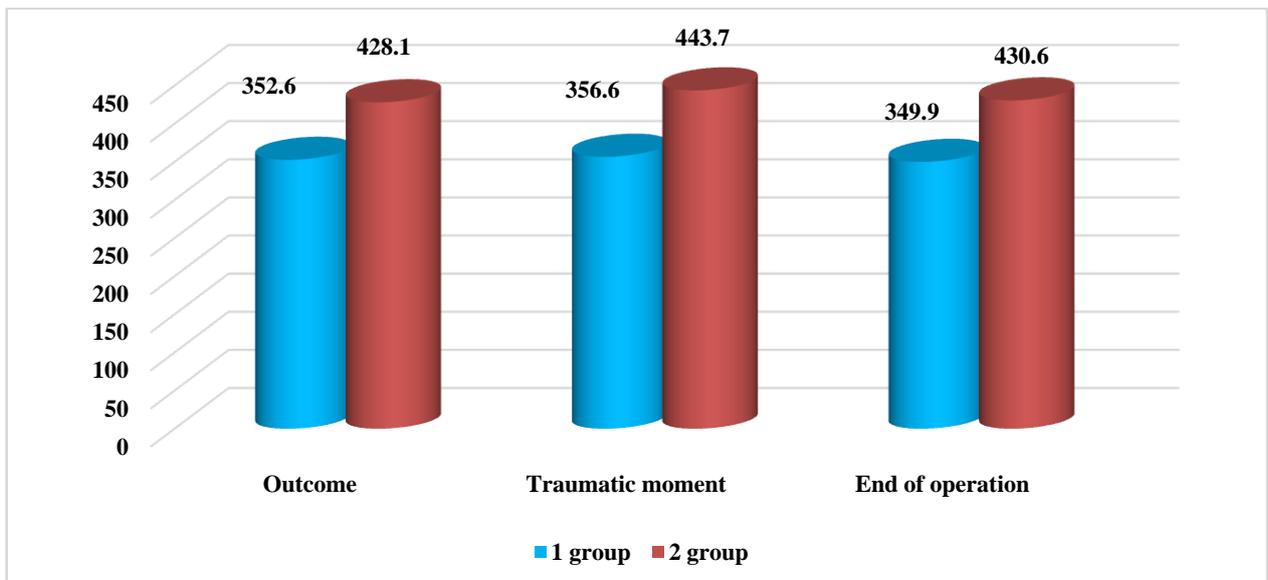


Figure 2. Dynamics of cortisol indicators at the stages of the study

Already at the initial level, an increase in the level of this parameter was noted in children in group 2 with a difference of 17.77% ($P > 0.05$) in relation to the data in group 1, with a certain increase both at the main stage of surgical intervention - by 19.63% ($P > 0.01$), and at the final - by 18.73% ($P > 0.01$), respectively. Fluctuations in the T3 level in both groups were insignificant at the stages of the operation, but in group 2 higher parameters were noted in relation to similar indicators in group 1. Thus, already at the initial stage, the obtained results indicated higher values of this parameter by 10.9% ($P > 0.01$) in group 2 patients. A certain increase in the controlled indicator was noted at the main stage of anesthesia, when the T3 level in the 2nd group of patients was 8.93% ($P > 0.01$) higher than in the 1st group, and at the end of anesthesia - 8.7% ($P > 0.01$) higher than similar indicators in the 1st group (Fig. 3).

The studies revealed an increase in T4 levels in patients of group 2 at all stages of anesthesia. Thus, the initial level of this parameter was 11.4% ($P > 0.05$) higher than in group 1 with a sufficient increase at the main stage of the operation - by 22.87% ($P < 0.05$). Its decrease at the stage of completion of anesthesia was insignificant - by 16.55% ($P > 0.001$) in group 2, from the indicator in group 1 (Fig. 4).

Thus, it can be noted that when conducting standard anesthesia with fentanyl and propofol in children during orthopedic operations, the T4 level tends to increase already at the initial stage, with a further tendency towards the final stage.

At the same time, the hormonal status indicators in the perioperative period in patients of group 2 were significantly increased, in relation to similar indicators in group 1. When assessing the level of cortisol, T3, T4, a fairly capacious increase in their values was observed in patients in group 2.

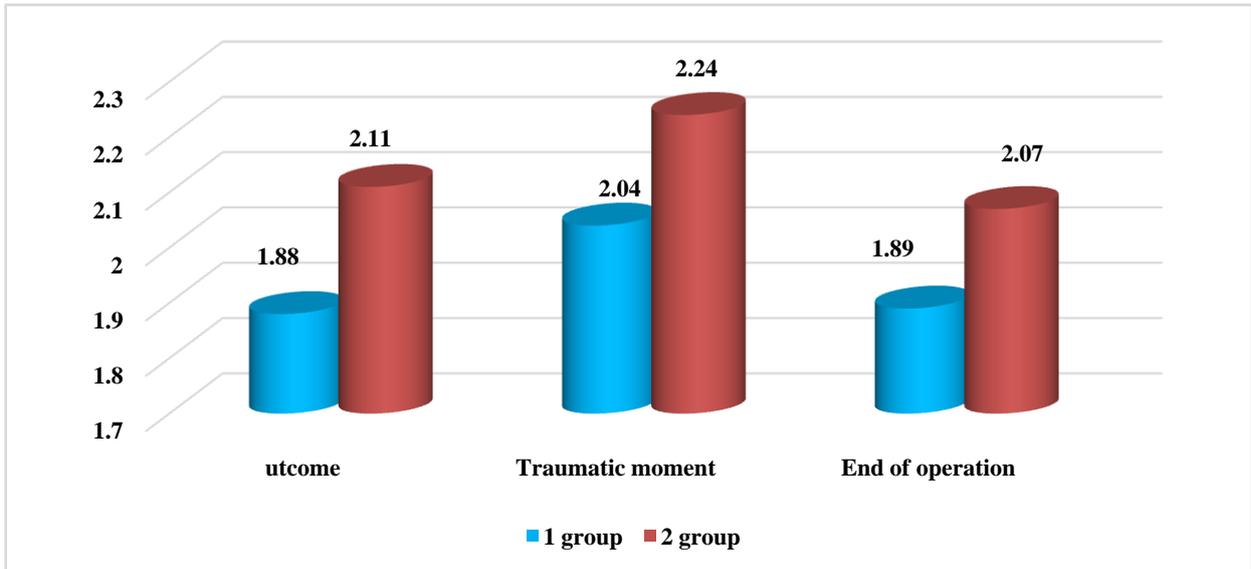


Figure 3. Changes in T3 values at different stages of the study

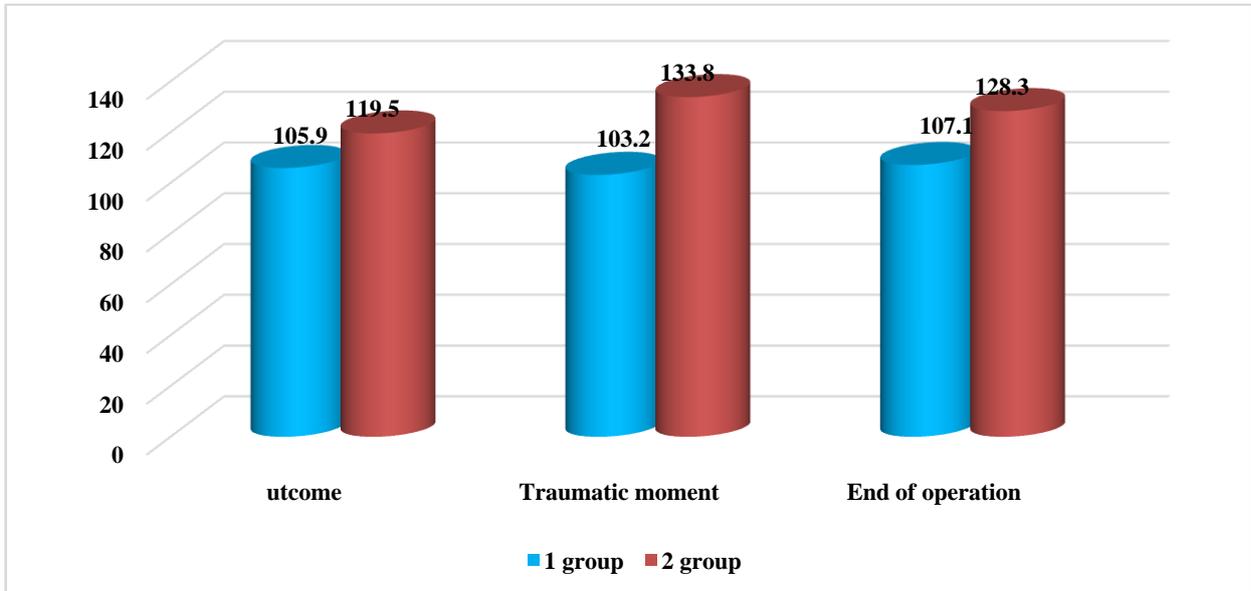


Figure 4. Dynamics of T4 indicators at different stages of the study

Thus, based on the conducted studies, it can be concluded that the implementation of the proposed anesthesia technique in patients of group 1 is significantly more effective and rational than standard anesthesia.

4. Conclusions

1. Combined general anesthesia based on low doses of fentanyl, sevoflurane and propofol is characterized by a smooth clinical course and the preservation of stability of systemic hemodynamic parameters in children during thoracoplastic surgeries.
2. Moderate increase in triiodothyronine (T3) with suppression of cortisol release at the stage of the traumatic moment of the operation confirms sufficient anti-stress protection under conditions of general anesthesia with sevoflurane, fentanyl and propofol.

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