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Advantages and disadvantages of intravenous total anesthesia for one day surgery in children

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Keypoints

The greatest number of critical incdents was noted with intravenous total anesthesia with a combination of ketamine, midazolam and fentanyl. Therefore this scheme of anesthesia does not fully meet the requirements for one day hospital.

Abstract

The choice of an anesthetic support option in the conditions of "one-day surgery" in children should be carried out taking into account a number of the following factors. First of all, it is a smooth introduction into anesthesia and rapid withdrawal from it immediately after the operation. We conducted a study to assess the clinical course of anesthesia with ketamine in combination with midazolam and fentanyl, to study central hemodynamics in 37 children aged 0 to 16 years who underwent surgical interventions for inguinal and umbilical hernia, dropsy of the testicles, phimosis, paraphimosis, cryptorchidism, rectal polyp.

Intravenous anesthesia with ketamine in combination with midazolam and fentanyl was characterized by the stability of the main hemodynamic parameters, no critical changes leading to death were recorded. The most pronounced fluctuations in hemodynamic parameters during anesthesia were noted at the traumatic moment of the operation. At this stage, total peripheral vascular resistance increased significantly, with a corresponding change in mean arterial pressure. There was a decrease in stroke volume and minute volume of blood circulation, despite compensatory tachycardia. It is most likely that these changes are associated with a lack of anesthesia. The data obtained during the study indicate the insufficient depth of this anesthesia regimen (ketamine + midazolam + fentanyl) to prevent reflex reactions and pain during operations. During the awakening period, a slow stabilization of blood circulation parameters was noted. The greatest number of critical incidents was noted with intravenous total anesthesia with a combination of ketamine, midazolam and fentanyl. Therefore, this scheme of anesthesia does not fully meet the requirements for surgical interventions in a one-day hospital.

Keywords

One-day surgery, general anesthesia, total intravenous anesthesia.

Introduction

The specificity of surgical interventions in the conditions of "one-day surgery" dictates its own requirements for the method and methods of anesthesia. On the one hand, according to J.P.Dechene (1978), where possible, it is advisable to use regional anesthesia, and if general anesthesia is necessary, preference should be given, given the duration of operations, to the use of those short-acting drugs that have minimal side effects. On the other hand, according to White P (2005), the question of the "best" method of anesthesia in each case should be considered individually in relation to a specific surgical intervention.

The main requirements for anesthesia allowance in the conditions of "one-day surgery" are as follows:

- ensuring maximum patient safety;
-creation of the best conditions for the work of the surgeon.

The choice of an anesthetic support option in the conditions of "one-day surgery" in children should be carried out taking into account a number of the following factors. First of all, it is a smooth introduction into anesthesia and rapid withdrawal from it immediately after the operation. It is also necessary to bear in mind the rapid recovery of consciousness of the child during observation in the postoperative ward and the possibility of early sending him home with the absence or minimal severity of pain, postoperative nausea and vomiting (3, 7, 8, 9, 19, 20).

An analysis of numerous literature has shown that the experience of some one-day hospitals confirms the possibility of using almost any type of anesthesia during surgical interventions. And anesthesiologists are well acquainted with them, yet there remains a need for special characterization of these drugs and methods (10, 11, 12, 13, 14, 15, 16, 17, 18).

It should be borne in mind that in all areas of surgery, a significant part is made up of a variety of invasive diagnostic and surgical interventions that do not require total muscle relaxation, which require effective and safe methods of general anesthesia with the patient's spontaneous breathing preserved. With a large flow of such widespread operations and diagnostic procedures, an important condition is the environmental safety of general anesthesia, which is almost impossible to ensure with mask inhalation anesthesia, therefore, in this area of activity of the anesthesiologist, intravenous anesthesia without the use of an inhalation component is an alternative option.

The use of non-inhalation agents for general anesthesia in pediatric anesthesiology has become possible in the last two decades due to the emergence of a new generation of intravenous anesthetics and analgesics. These funds should have the following qualities: 1) the speed of the onset of effect (within minutes or even less); 2) ease of administration (low viscosity) and painlessness of injection; 3) minimal cardiorespiratory depression; 4) the absence of side effects in the form of the appearance of spontaneous movements.

The main advantages of total intravenous anesthesia are:

- imperceptible for the patient, but rather quick introduction to anesthesia with the maximum elimination of mental trauma (some means allow anesthesia to be started in the ward);
- no irritation of the respiratory mucosa, minimal effect on parenchymal organs, rare nausea and vomiting;
- technical simplicity of equipment.

The main disadvantages of this type of anesthesia include:

- low controllability of anesthesia and the inability to stop it as soon as the need arises;
- the absence of many intravenous anesthetics of the ability to block adverse reflex reactions to surgical trauma;
- the tendency of many non-inhalation anesthetics to accumulate due to long-term circulating metabolic products, which makes it difficult to use them during long-term operations and limits their repeated use after a short time interval;
- distinct convulsive activity for a number of non-inhalation anesthetics.

To date, barbiturates, ketamine, benzodiazepines and propofol are used in pediatric anesthesiology. All these drugs affect respiration, intracranial pressure and hemodynamics (4, 5). When using them in pediatric anesthesiology, both in the form of boluses and in the form of continuous infusion, it is necessary to take into account the peculiarities of the pharmacokinetics of the child's body. This is a larger volume of the central chamber and faster clearance compared to adult patients. Metabolic possibilities even in children under one-year-old are very high due to the relatively high fraction of cardiac output that perfuses the liver (6, 18). However, in neonates, especially preterm infants, the possibility of immaturity of hepatic enzymes and the possibility of impaired clearance of intravenous drugs should be considered (16, 21, 22, 23).

Material and research methods

We conducted a study to assess the clinical course of anesthesia with ketamine in combination with midazolam and fentanyl, to study central hemodynamics in 37 children aged 0 to 16 years who underwent surgical interventions for inguinal and umbilical hernia, dropsy of the testicles, phimosis, paraphimosis, cryptorchidism, rectal polyp and varicocele. The study was conducted in the following six stages:

Stage I - initial data:
Stage II - after premedication;
Stage III - induction into anesthesia;
Stage IV - skin incision;
Stage V - traumatic moment of the operation;
Stage VI - the awakening of the patient.

To assess the physical condition of patients, in addition to studying the anamnesis in a conversation with parents, a general clinical examination, the frequency and nature of the pulse and respiration, blood pressure, skin color and the degree of its moisture, skin turgor, the following indicators were also studied:

1. Study of laboratory blood parameters (blood group, Rh factor, hemogram, serological tests for HIV, HBS, HCV, PW).
2. General analysis of urine.
3. Blood clotting time.
4. Prothrombin index.
5. Pulse oximetry.
6. Electrocardiography.
7. Chest x-ray and, if necessary, computed tomography of the chest.

Induction anesthesia in patients of this group was carried out by intravenous bolus administration of ketamine at a rate of 2 mg/kg. 20 minutes before surgery, patients in this group were premedicated with midazolam 0.4 mg/kg orally. Anesthesia was maintained by intravenous bolus administration of fentanyl 3 µg/kg and ketamine 1 mg/kg. All patients were on spontaneous breathing with inhalation of an oxygen-air mixture (FiO2=0.5) through a face mask. This group was divided into 3 subgroups depending on age: IA (n=12) - age 0-3 years, IB (n=13) - age 4-7 years and IC (n=12) - age 8-16 years.

Research results

In addition to objective indicators of the adequacy of anesthesia, the depth of anesthesia and the duration of anesthesia induction time were assessed according to clinical signs: the position of the eyeballs, pupil width, lacrimation, corneal and ciliary reflexes, the nature of breathing and muscle tone. Critical incidents were also assessed, such as laryngospasm, bronchospasm, cough, moderate and critical hypoxia, hypoventilation and respiratory arrest, nausea and vomiting.

Midazolam 0.4 mg/kg was administered orally 20 minutes before the start of the operation. Induction anesthesia was carried out by intravenous administration of ketamine at a dose of 2 mg/kg, fentanyl 3 µg/kg and ketamine 1 mg/kg were administered intravenously to maintain anesthesia. Induction into anesthesia proceeded smoothly, large-scale horizontal nystagmus, single muscle twitches, and transient hypertonicity were noted. The loss of the ciliary reflex was noted after 86.6 sec. ± 12.3 from the onset of anesthesia.

Upon reaching the surgical stage of anesthesia, the pupil narrowed, the eyeballs were placed in the center, in some cases, lacrimation was noted. The total time of induction into anesthesia was 155 sec.±12.6. The clinic of ketamine anesthesia was smoothed due to the use of sufficient doses of midazolam.

During surgery and in the immediate postoperative period, the following critical incidents were recorded: during induction of anesthesia, 5 (13.5%) children had short-term apnea or hypoventilation (8.8%), moderate hypoxia in 6 patients (16.2%), critical hypoxia in 3 patients (8.1%), laryngospasm (16.2%) in 6 children, bronchospasm in 2 patients (5.4%), motor sweeping movements in 11 patients (29.7%) , 7 children (18.9%) had nausea and vomiting, 8 patients (21.6%) had prolonged secondary sleep and diplopia in 4 (10.8%) patients.

Table 1.1
Indicators of hemodynamics and the respiratory system during intravenous anesthesia ketamine in combination with midazolam and fentanyl in children aged 0-3 years of group IA (n=12)
Note: statistical significance of differences in indicators in relation to the original data: * - p < 0.05; ** – p < 0.01; *** – p < 0.001

Indicators	I stage	II stage	III stage	IV stage	V stage	VI stage
HR	113,1±2,7	109,7±2,7	118,6±2,6	121,4±2,6 *	122,9±2,3 *	112,6±2,3
BPs	93,0±1,0	87,2,0±1,4 **	100,0±2,0 **	104,3±1,6 ***	106,7±1,7 ***	88,4±1,3 **
BP_D	47,3±1,0	44,9±1,0	50,3±0,9 *	54,2±1,0 ***	57,8±0,8 ***	47,1±0,9
MAP	62,6±0,7	59,0±0,9 **	66,9±1,0 **	70,9±1,0 ***	74,1±0,9 ***	60,9±0,8
SVH	34,0±1,1	33,7±0,8	34,2±1,2	32,2±0,9	29,4±0,8 **	32,0±1,1
MVBC	3.84±0,14	3,69±0,12	4,04±0,13	3,90±0,13	3,60±0,10	3,60±0,12
TPVR	1966,5±73,0	1908,7±71,6	1996,4±65,2	2165,6±77,9	2385,5±70,6 **	1996,9±91,3
BR	27,6±0,5	26,0±0,5 *	29,4±0,5 *	29,7±7,6 *	29,9±0,7 *	27,5±0,4
TV	103,0±2,4	100,3±2,5	90,0±1,7	89,7±1,7	90,0±1,7	101,4±2,5
SpO2	98,3±0,1	97,4±0,2 **	96,5±0,2 ***	95,7±0,1 ***	95,3±0,1 ***	95,3±0,1 ***
PetCO2	38,8±0,1	40,0±0,2 ***	41,5±0,4 ***	43,5±0,4 ***	41,7±0,4 ***	39,2±0,4
RPP	105,0±1,9	95,3±1,8 **	118,3±2,4 ***	126,4±2,1 ***	130,8±1,9 ***	99,3±1,6 *

Table 1.2
Indicators of hemodynamics and the respiratory system during intravenous anesthesia ketamine in combination with midazolam and fentanyl group IB
in children aged 4-7 years (n=13)
Note: statistical significance of differences in indicators in relation to the original data: * - p < 0.05; ** – p < 0.01; *** – p < 0.001

Indicators	I stage	II stage	III stage	IV stage	V stage	VI stage
HR	97,6±2,1	91,8±1,8 *	105,6±2,3 *	110,2±1,9 ***	112,4±1,8 ***	108,5±2,6 **
BPs	97,1±1,4	90,5±1,0 ***	102,7±1,9 *	109.9±1,5 ***	112,8±1,6 ***	98,2±1,9
BP_D	60,7±1,8	56,8±1,7	63,0±1,6	66,6±1,2 *	68,3±1,5 **	62,5±1,9
MAP	78,5±1,6	68,0±1,4 *	76,2±1,6	81,9±1,2 ***	83,2±1,4 ***	74,4±1,6
SVH	49,6±3,8	50,7±3,9	49,9±4,4	49,5±4,5 *	49,1±4,2 *	48,3±3,8 *
MVBC	4,80±0,37	4,62±0,35	5,22±0,45	5,42±0,49	5,50±0,48	5,26±0,47
TPVR	1744,1±144,1	1687,9±136,4	1768,8±194,4	1868,0±235,2 *	1873,0±232,1 *	1674,4±193,6
BR	25,1±0,5	22,7±0,5 **	27,0±0,5 *	28,0±0,6 ***	28,2±0,4 ***	25,4±0,6
TV	142,6±3,9	141,0±3,6 ***	122,5±2,6 ***	121,1±2,1 ***	121,2±2, 2***	139,8±3,8
SpO2	100,0±0,0	98,5±1,1	98,2±1,7	97,5±1,8 *	97,3±1,9 *	98,3±2,3
PetCO2	36,7±0,2	38,0±0,3 ***	39,7±0,4 ***	40,9±0,4 ***	40,2±0,4 ***	37,2±0,2
RPP	94,5±1,3	83,0±1,5	108,3±2,7	121,1±2,6 ***	126,8±2,4 ***	107.0±4,3 *

Table 1.3
Indicators of hemodynamics and the respiratory system during intravenous anesthesia ketamine in combination with midazolam and fentanyl IC subgroup
in children aged 8-16 years (n=12)
Note: statistical significance of differences in indicators in relation to the original data: * - $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$

Indicators	I stage	II stage	III stage	IV stage	V stage	VI stage
HR	82,2±1,2	78,1±1,7	95,6±2,0 ***	101,3±1,9 ***	104,8±1,8 ***	87,8±2,1 **
BPs	110,2±2,5	101,3±2,0 *	115,8±2,0	120,4±1,4 **	119,9±2,3 **	105,5±1,6
BP_D	72.7±1,8	66.2±1,0 **	73.3±2,1	76.4±1,8 *	78.1±1,5 *	69.2±1,5
MAP	85,2±2,	77,9±1,3 **	87,5±2,0	91,1±1,6 *	92,0±1,6 *	81,3±1,3
SVH	48,2±1,3	50,9±0,9	50,3±2,1	49,2±1,9 *	47,1±1,6 *	49,7±1,8 *
MVBC	3,97±0,15	3,98±0,13	4,84±0,28 *	5,00±0,25 **	4,95±0,21 ***	4,36±0,16
TPVR	2268,6±131,7	2064,2±93,9	1996,5±139,5	1990,6±125,4 *	1978,0±100,5 *	1968,7±86,9
BR	18,8±0,7	17,1±0,7	20,5±0,7	21,4±0,5 **	21,5±0,6 **	18,8±0,7
TV	227,2±17,4	225,2±17,5	195,3±14,7	193,8±14,3	193,8±17,5	223,8±17,1
SpO2	98,9±0,1	98,0±0,0 ***	96,9±0,1 ***	96,4±0,2 ***	96,1±0,2 ***	96,2±0,2 ***
PetCO2	36,0±0,2	37,0±0,2 **	37,6±0,3 ***	38,3±0,3 ***	37,6±0,3 ***	36,3±0,2
RPP	90,4±2,2	78,9±1,9 ***	110,6±2,4 ***	121,8±2,2 ***	125,6±2,9 ***	92,6±2,3

We conducted a study of central hemodynamics, respiratory function with intravenous administration of ketamine in combination with midazolam and fentanyl in children of different age groups with minor surgical interventions.

The main changes in the indicators of central hemodynamics relative to stage I during intravenous anesthesia with ketamine in combination with midazolam and fentanyl are presented in tables 1.1, 1.2 and 1.3.

During the induction of anesthesia in all age groups, the performance of the cardiovascular system mainly remained at the level of the initial values, however, certain hemodynamic changes were identified that characterize the effect of ketamine and midazolam (Fig. 1.1 - 1.4).

So, during induction of anesthesia, the heart rate increased in the group of patients aged 0-3 years, on average by 4.9% ($p < 0.01$), and in patients aged 4-7 years, 8.2% ($p < 0.05$), and in patients 8-16 years old by 16.3% ($p < 0.001$) (Fig. 1.1).

At the same time, there was an increase in mean arterial pressure at the age of 0-3 years, by an average of 6.9% ($p < 0.01$), and in patients aged 4-17 years by 4.7% ($p < 0.01$), and in patients 8-16 years old by 2.7% ($p<0.001$) (Fig. 1.2).

A decrease in vascular tone was demonstrated in terms of total peripheral vascular resistance, which turned out to be greater in patients aged 8-16 years, by an average of 12.0% ($p < 0.001$), and in patients aged 0-3 years 1.5 % ($p < 0.001$), and in patients 4-7 years old by 1.4% ($p < 0.01$). The increase in diastolic pressure was 6.3% ($p < 0.05$), 3.8% ($p < 0.01$) and 0.9% ($p < 0.01$), and systolic pressure by 7.5% ($p < 0.01$), 5.8% ($p<0.01$) and 5.1% ($p<0.01$) in the respective age groups.

Thus, the picture of central hemodynamics during induction anesthesia with ketamine in combination with midazolam corresponded to the picture of transient hyperdynamia. The beginning of the operation was accompanied by an increase in central hemodynamics, which was associated with the presence of pain and required additional administration of fentanyl.

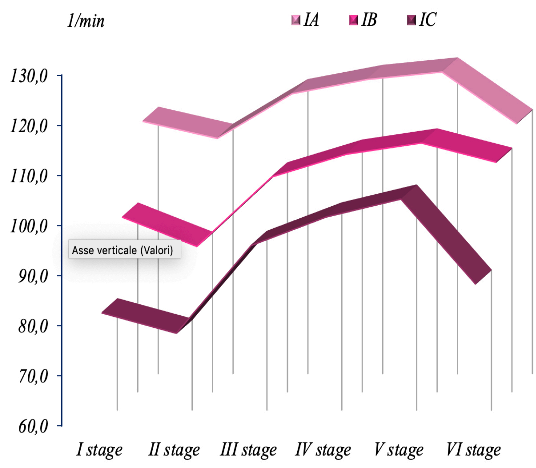

Figure 1.1. Dynamics of changes in heart rate in children in study groups.

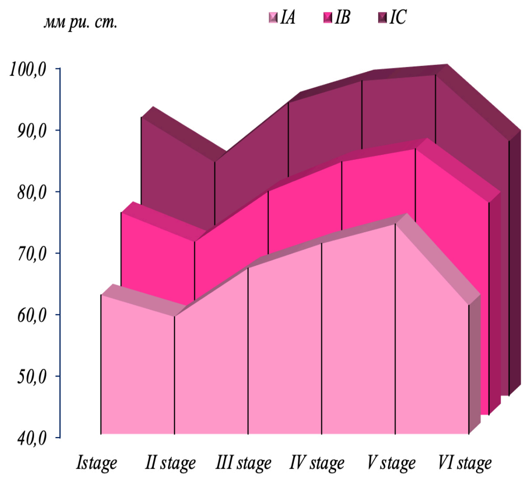

Figure 1.2. Dynamics of changes in SBP in children

The traumatic moment of the operation was accompanied by an increase in the minute volume of blood circulation by 1.6%, 14.7% ($p < 0.05$), 24.7% ($p < 0.001$) in the corresponding age groups due to an increase in mean arterial pressure by 18.4 % ($p<0.001$), 14.2% ($p<0.001$), 8.1% ($p<0.001$) compared to baseline.

An increase in RPP by 24.6% ($p < 0.001$), 34.1% ($p < 0.001$), 38.9% ($p < 0.001$) in the corresponding age subgroups compared with the baseline also indicated that the patient was in a stressful state.

In the postoperative period in patients of older age subgroups, the observation of the hyperdynamic type of blood circulation continued.

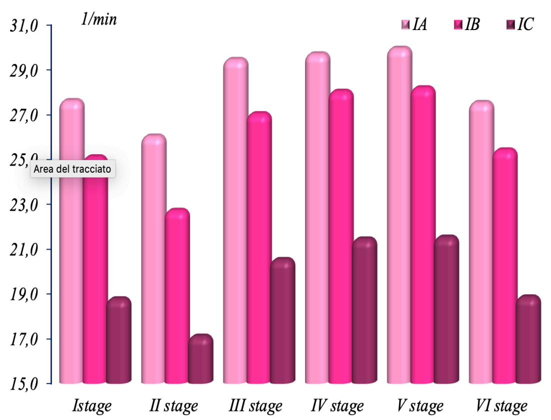

Figure 1.3. Dynamics of changes in respiratory rate in children in study groups.

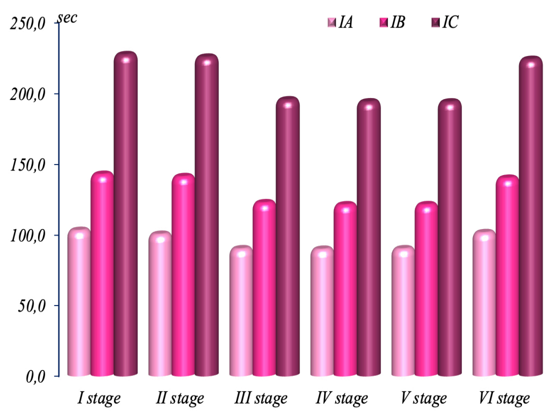

Figure 1.4. Dynamics of changes volume tidal in children in study groups.

Thus, heart rate increased at the age of 4-7 years by 11.1% ($p < 0.01$), RPP - by 13.2% ($p < 0.05$), minute volume of blood circulation - by - 9.5% and at age 8-16 years old by 6.9% ($p < 0.05$), and RPP - by 2.4% ($p < 0.05$), minute volume of blood circulation - by 9.7%, respectively.

When analyzing the parameters of external respiration, it was found that at the third and fourth stages of the study, there was an increase in respiratory rate by 10.8% ($p < 0.01$) and 11.5% ($p < 0.01$), respectively. This was explained by the appearance of pain and the inadequacy of anesthesia. Due to shallow breathing, there was a decrease in tidal volume at the third and fourth stages by 13.8% ($p<0.01$) and 14.4% ($p<0.01$), respectively.

We also carried out the clinical course of the early postoperative period during anesthesia using ketamine in combination with midazolam and fentanyl in the 4 to 7 age group. The awakening of patients in this group proceeded relatively smoothly. Eye opening was recorded after 581.8±62.5 sec. after operation. The recovery of consciousness was slow, the execution of a simple command of the anesthesiologist was noted after 839.1±78.6 sec. The maximum value of 6 points on the Aldret scale was not reached by the 20th minute. 5 minutes after the operation, the average was 3.16±0.41 points, with a minimum level of 3 points in the group, at 10 minutes - 4.69±0.25 with a minimum value of 3 points, at 15 minutes - 5.6±0, 16 with a minimum value in the group of 4 points. Patients were transferred to the ward of the surgical department after an average of 1105±45.6 sec. Entering into a dialogue with the anesthesiologist was recorded after 1370.1±142 sec. after the end of the operation.

The level of anxiety in the postoperative period according to the Hannallah scale at 10 minutes after the operation was 1.18±0.39 points, with a maximum value of 2 points in the group, and 30 minutes after the operation, the indicator was 1.35±0.31 points with a maximum value of 3 points and 1 hour after the operation - 1.6±0.22 points with a maximum value in the group of 2 points.

Most patients in the postoperative period had a long secondary sleep, disorientation in time and space, dizziness. However, 2 hours after the operation, all children were contact and adequate.

We also studied the clinical course of the early postoperative period during anesthesia using ketamine in combination with midazolam and fentanyl in the age group from 8 to 16 years. Awakening in this group proceeded calmly, with a slow recovery of consciousness. Eye opening was recorded after 621.1±35.7 sec. after the operation, and the execution of a simple command of the anesthesiologist was noted at 841.2±44.0 sec. Mean anesthesia time was 1412.1±90.5. In the absence of external stimuli, the children quickly fell asleep again. The maximum score of 6 on the Aldret Awakening Scale was not reached at 20 minutes. At 5 minutes, the average was 3.8

points, with the minimum value in the group being 3 points, at 10 minutes after the end of the operation, a level of 4.62 ± 0.18 points was recorded with the lowest value of 4 points, at 15 minutes, a value of 5.43 was noted ±0.12 points with a minimum value in the group of 5 points and at 20 minutes the average value was 5.8±0.09 points with a minimum value of 5 points.

During the next hour after the operation, secondary sleep was noted. With external stimulation, the children were sometimes able to correctly answer simple questions and execute commands, but without irritation they quickly fell asleep again. Within two hours after the operation, the children were disoriented in time and space and often complained of dizziness and nausea. Only by the fourth hour of the postoperative period, the patients were contact, adequate and transportable.

Conclusion

Intravenous anesthesia with ketamine in combination with midazolam and fentanyl was characterized by the stability of the main hemodynamic parameters, no critical changes leading to death were recorded. The most pronounced fluctuations in hemodynamic parameters during anesthesia were noted at the traumatic moment of the operation. At this stage, total peripheral vascular resistance increased significantly, with a corresponding change in mean arterial pressure. There was a decrease in stroke volume and minute volume of blood circulation, despite compensatory tachycardia. It is most likely that these changes are associated with a lack of anesthesia. The data obtained during the study indicate the insufficient depth of this anesthesia regimen (ketamine + midazolam + fentanyl) to prevent reflex reactions and pain during operations. During the awakening period, a slow stabilization of blood circulation parameters was noted. The greatest number of critical incidents was noted with intravenous total anesthesia with a combination of ketamine, midazolam and fentanyl. Therefore, this scheme of anesthesia does not fully meet the requirements for surgical interventions in a one-day hospital.

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