Application of controlled arterial hypotension in endoscopic rhinosurgery

Darius Činčikas, Juozas Ivaškevičius[1]
Vilnius Missionary Hospital, Lithuanian Rhinology Center,
[1]Department of Anesthesiology and Reanimatology, Vilnius University, Lithuania

Key words: *FESS, intraoperative bleeding, induced hypotension.*

Summary. *Intraoperative bleeding is one of the major problems in endoscopic surgery of sinuses. In the case of the expanded process, still more numerous interventions are performed with general anesthesia.*

The objective of research is to compare intraoperative hemorrhage and the visibility of the operative field during normotension and hypotension anesthesia caused by nitroglycerin and captopril when performing endoscopic operations of accessory nasal sinuses. Fifty-two patients of physical health state 1–2 according to ASA were examined: for 32 the controlled hypotension (Group H) was applied, 20 patients underwent operations in normotension (Group N). All patients on the eve of the operation were premedicated with diazepam; Group H patients on the day of operation received 6.25 mg of captopril. Anesthesia was carried out with fentanyl and halothane steam in the 50:50% mixture of oxygen and laughing gas. In Group H arterial blood pressure was lowered by nitroglycerin infusion. The average arterial blood pressure was maintained in GroupH within the limits of 50–60 mmHg. Hypotension was coordinated with the rising of the head-bed of the operating table at 5°. Hemorrhage was measured by collecting blood with the pump graded with the precision of 25 ml. The visibility of the operative field was evaluated subjectively every 15 minutes according to the scale of 5 points proposed by Fromm. In both groups the average arterial blood pressure values as well as the values of the frequency of heart contractions differed statistically significantly. In the hypotensive group, hemorrhage during operation was less, on the average, (208 ml) than in Group N (349.2 ml). The visibility of the operative field was by one point, on the average, better than in Group H. No anesthetic complications were observed during investigation.

In summary, it is possible to state that the controlled arterial hypotension caused by captopril and nitroglycerin reduced significantly intraoperative hemorrhage and improved the visibility of the operative field in endoscopic rhinosurgery.

Introduction

Lithuanian Rhinology Center performs approximately 200 endoscopic surgeries of sinuses (FESS – functional endoscopic surgery of sinuses). This is the method of minimum invasion, which is currently widespread and has become the main one on the global scale for treatment of patients with sinus pathology (1, 2, 4).

Intraoperative bleeding, which reduces visibility in the operative field, is one of the major problems of such interventions (1). Complicated anatomic structure, its unique variations, vicinity of delicate cranial base, brain, eyes, blood vessels and nerves requires for the surgeon to know anatomy in detail and to precisely identify structures (4). The authors, having completed analysis of FESS surgery complications, state that abundant bleeding during surgeries undoubtedly is among the factors able to cause complications (3, 4, 11, 12). Upon reduced visibility the time of intervention extends. Increased bleeding sometimes causes finishing surgeries before the due time, when targets raised at the beginning are given up in order to avoid possible complications.

In endoscopic rhinosurgery local anesthesia is considered to be a traditional one (3). Its basic advantage is lower bleeding in the operative field. But in

Correspondence to D. Činčikas, Vilnius Missionary Hospital, Subačiaus 26, 2600 Vilnius, Lithuania
E-mail: dariuscincikas@takas.lt

more complicated cases - in an expanded process, when large-scale intervention is planned, priority is given to general anesthesia for performance of subsequent surgeries. Recently the increasing number of patients is operated under a general anesthesia.

Improvement of intraoperative visibility while reducing bleeding is and important task for an anesthetist during a FESS. For this purpose we used the method of induced hypotension (IH) coordinating it with the patient's positioning on an operative table. During IH, the average arterial blood pressure (AABP) was maintained within the limits of 50-60 mmHg. The state of "hypotension" was achieved by reducing the peripheral blood vessel resistance, reducing the heart volume per minute and by inter-coordinating these two effects (5). Most frequently peripheral vasodilators, beta-blockers, volatile anesthetics are used to cause IH, and recently combinations of several medications are often selected (6). Patients are most often placed with the rising of the head-bed at 5°, thus developing a "postural" hypotension.

The objective of our research is to compare intraoperative hemorrhage and the visibility of the operative field during normotension and hypotension anesthesia caused by nitroglycerin and captopril.

Material and methods

Fifty-two patients, who underwent endoscopic surgeries (FESS), were examined with polyposis of accessory nasal sinuses. Patients were grouped into two groups: the hypotension group (Group H) and the normotension group (Group N).

The age of the patients was between 16 and 61 years and physical health state 1-2 according to ASA. The study did not include patients with the cardiovascular system pathology – cardiac failure, badly induced hypertension, as well as patients with blood system pathology and those administering aspirin or other medications affecting coagulation system. Patients with kidney or liver dysfunctions, as well as anemia (Hb<10g/dl) were not included, as well.

All patients on the eve of the operation were premedicated with 5-10 mg diazepam, and on the day of operation they received 5 mg midazolam intramuscular injections 30 minutes before anesthesia. Group H patients received 6.25 mg of captopril per os one hour before anesthesia. Preliminary anesthesia was carried out with fentanyl 1-2 μg/kg and thiopental 6-8 mg/kg intravenous injections. Patients were intubated after intravenous injection of muscle relaxants atracurium (0.5-0.7) mg/kg or succinylcholine 1.5 mg/kg. Anesthesia was maintained with halothane steam (up to 1.5 MAC) in the 50:50 percent of oxygen and laughing gas, with additional fentanyl and sometimes muscle relaxant doses. For patients of Group H glycerol trinitrate (nitroglycerin) infusions were started right after intubation, dosing with an automatic infusion syringe at 0.5-5 μg/kg rate. Upon 50-60 mmHg AABP limit gradually reached, surgical intervention was started. All patients had their lateral nasal walls infiltrated with 0.5-2.0 ml 1% lidocaine with adrenaline 1/100 000–200 000 solution before cutting. Nitroglycerine infusions were discontinued and quantities of anesthetics were reduced 15-20 minutes before end of surgeries.

Patients after surgery, upon their muscular tonus and sufficient natural breathing restored, were extubated and transferred to a wake-up ward foro further monitoring.

Before surgeries hemoglobin (Hgb), hematocrit (Ht), serum, urea, electrolyte, APTT analyses were made for patents. ECG was done for all patients. These analyses were repeatedly performed during the post-surgical time period. During anesthesia arterial blood pressure was measured every 3 minutes in non-invasive oscillometric way, and its systolic, diastolic and average values were recorded. Frequency of heart contractions was recoded at the same rate. To have higher ischemic sensitivity V5 ECG derivation was monitored by 3-electrode-modified system; ST segment was observed. Perioperative diuresis was monitored.

Hemorrhage was measured by collecting blood with the pump graded with the precision of 25 ml. For evaluation of the visibility of the operative field during FESS the quality scale proposed by Fromm and Boezzart (2) was used:

0 – no bleeding.

1 – slight bleeding – blood evacuation not necessary.

2 – slight bleeding – sometimes blood has to be evacuated.

3 – low bleeding – blood has to be often evacuated. Operative field is visible for some seconds after evacuation.

4 – average bleeding - blood has to be often evacuated. Operative field is visible only right after evacuation.

5 – high bleeding – constant blood evacuation is needed. Sometimes bleeding exceeds evacuation. Surgery is hardly possible, sometimes – impossible at all.

Table 1. **Intraoperative hemorrhage and quality of the operative field**

Characteristic	Group H	Group N
Hemorrhage, ml	208.0±92.8*	349.2±162.2*
Operative field visibility, points	2.4±0.7*	3.4±0.7*

*average ± standard deviation p<0.05.

Table 2. **Demographical data, physical health state, adjacent pathology, duration of surgery and anesthesia for examined patients**

Characteristic	Group H	Group N
Males	17	11
Females	15	9
Age, years	44.1±11.2*	45.0±12.3*
Weight, kg	76.2±13.2*	80.1±16.0*
ASA-1	11	7
ASA-2	21	13
Bronchial astma	6	4
Hypertonic disease	5	4
Diabetes	2	1
Allergy	6	3
Other pathologies	3	2
Duration of surgery, min	64.8±18.8*	73.3±26.0*
Duration of anesthesia, min	96.8±20.8*	103.0±26.2*

*average ± standard deviation p>0.05.

Bleeding in the operative field was subjectively evaluated by surgeons every 15 minutes. Two surgeons with long experience in endoscopic surgeries took part in the research.

Student criterion was applied for comparison of indicators for both groups. The difference was considered to be statistically significant, if a respective p-value was below 0.05.

Results

Fifty-two patients were examined: for 32 the controlled hypotension (Group H) was applied, 20 patients underwent operations in normotension (Group N). Table 2 specifies age, weight and sex of patients. Age and weight for patients of both groups had no statistically significant differences (p=0.77 and p=0.64). There was no statistically important difference between the physical health state according to ASA and morbidity between the groups in terms of frequency and type. Adjacent pathologies were diagnosed for 68.2% of Group H patients and for 63% of Group N patients. Out of Group H patients 27.3% had bronchial asthma, 22.7% had the hypertonic disease, 9% had diabetes, 27.3% were allergic to medications or other substances, and 13.6% of patients had other pathologies. In Group N 30.7% patients had bronchial asthma, 30.7% had the hypertonic disease, 7.6% had diabetes, 23% were allergic, and 15.4% of patients had other pathologies (Table 2). For Group H duration of surgery and anesthesia was shorter, but this difference is not statistically important. Opioid quantities used for both groups were similar (average 3.32±1.79 μg/kg fentanyl for Group H and 3.15±2.05μg/kg fentanyl for Group N). When dosing halothane, its concentration did not exceed 1.5MAC in both groups. Group H had nitroglycerine infusion since intubation up to the end of surgery at the rate of 0.79±0.34μg/kg/min.

Difference of (pre-anesthetic) average arterial blood pressure for patients was of no statistical significance: it represented 100.47±12.36 mmHg for patients under captopril and for Group N it was 106.10±15.21 mmHg (p-0.15). When analyzing AABP fluctuations further (Fig. 1) we see differ-

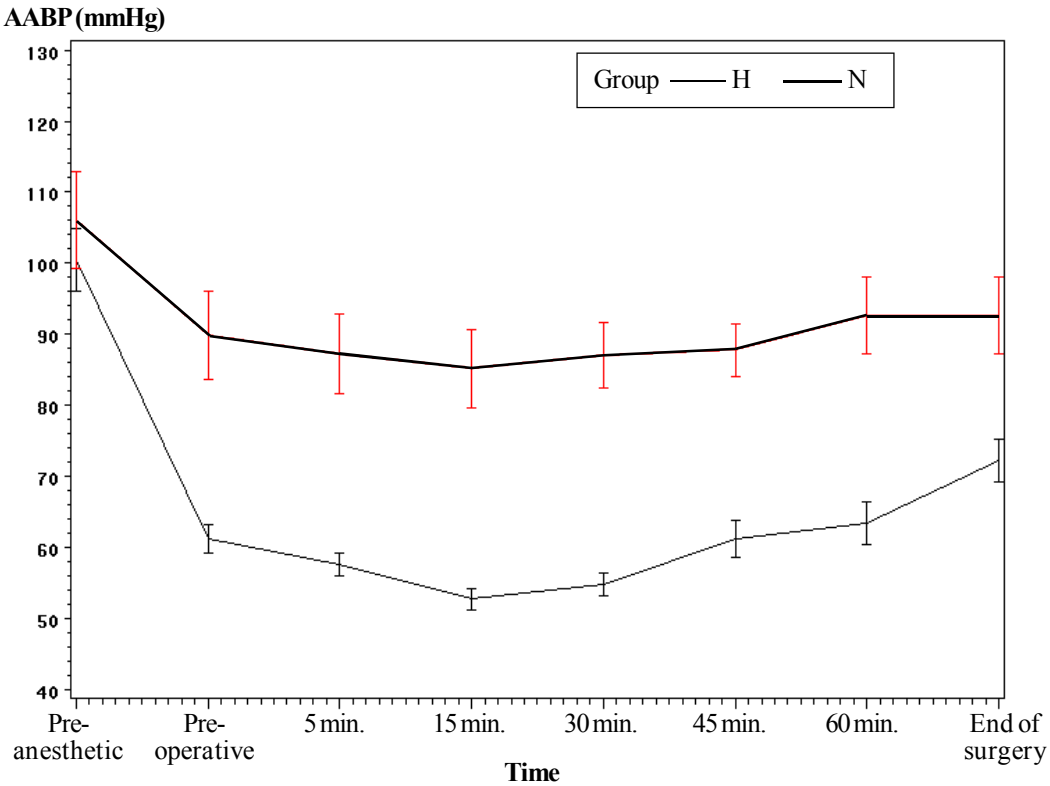

Fig. 1. **AABP fluctuations in Groups H and N**

The pre-anesthetic AABP in Groups H and N has no significant differences ($p>0.05$). Pre-operative on the 5th, 15th, 30th, 45th, 60th min. and at the end of the surgery AABP for the two groups differs significantly ($p<0.05$).

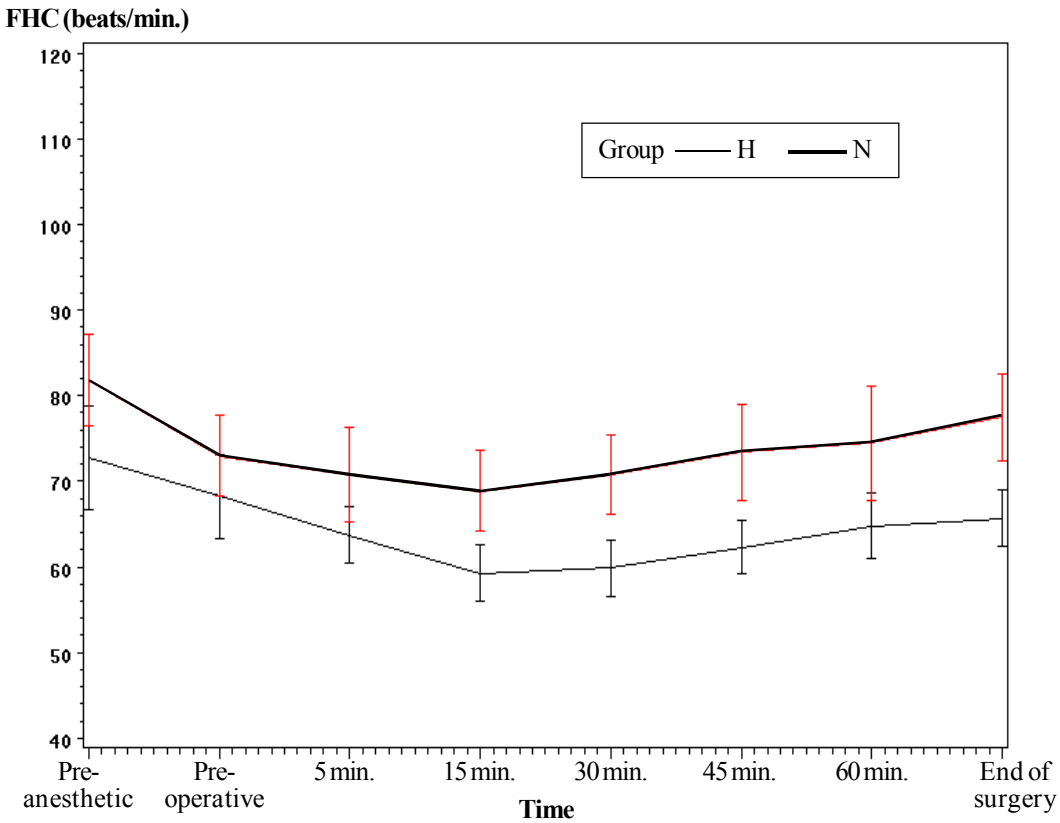

Fig. 2. **Fluctuation of FHC in Groups H and N**

FHC is significantly different for the two groups both before anesthesia and during the entire anesthesia time period ($p<0.05$).

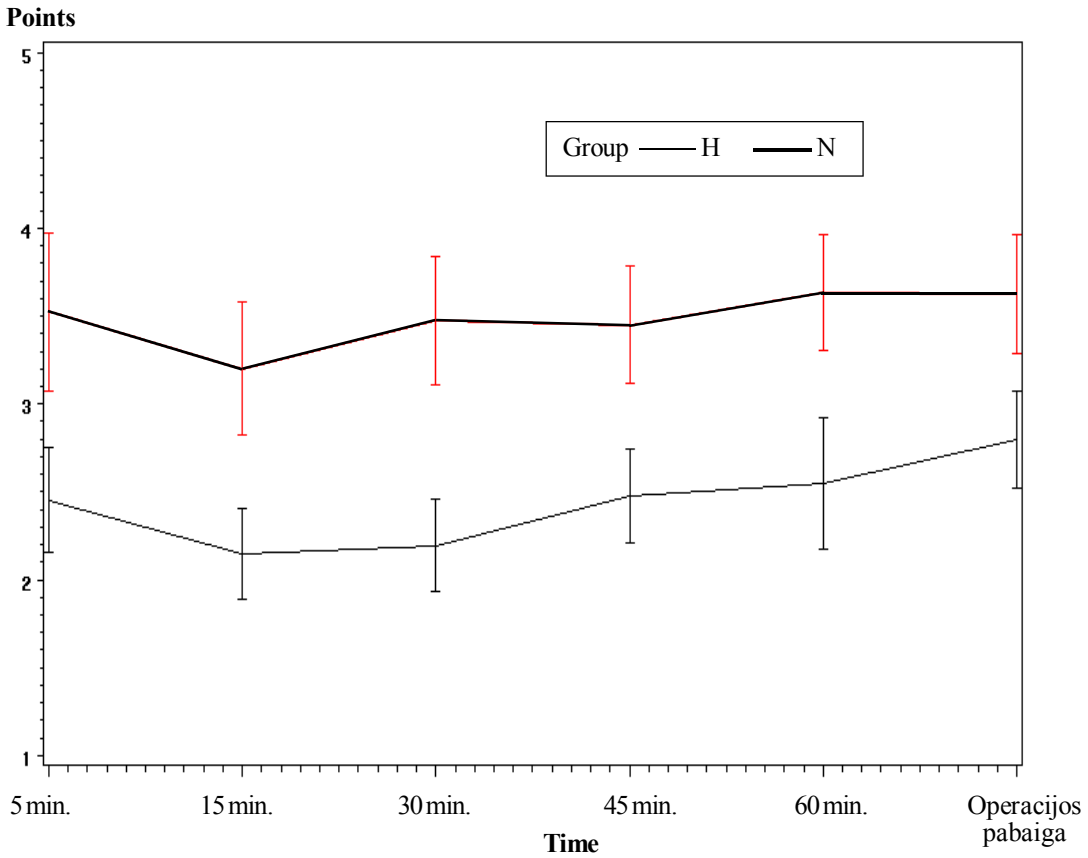

***Fig. 3.* Quality of the operative field in points in Groups H and N**

Quality of operative field differs significantly on the 5th, 15th, 30th, 30th surgery min. and at the end of the surgery ($p<0.05$).

ences between the groups increasing significantly during anesthesia, upon nitroglycerin infusion: 15th min. AABP in Group H – 52.72±4.17 mmHg, in Group N – 85.15±12.23 mm Hg ($p<0.0001$), at the end of surgery – in Group H - 72.16±8.44 mmHg, and in Group N – 92.70±12.11 mm Hg ($p<0.0001$). Frequency of heart contractions (Fig. 2) for (pre-anesthetic) active patients in Group H was 72.81±17.10 t/min, and for Group N – 81.75±11.98 t/min ($p<0.05$). On the 15th surgery minute FHC in Group H was 59.28±9.28 t/min, and for Group N – 68.85±10.56 t/min ($p<0.05$); at the end of surgery for Group H it was 65.69±9.44 t/min and 77.50±11.42 t/min for Group H ($p<0.05$).

Table 1 shows quantities of blood loss (ml) during surgeries and rated visibility of the operative field. In Group H hemorrhage was statistically significantly lower. The visibility of the operative field was by 1 point, on the average, better for the hypotensive group ($p<0.05$) (Fig. 3).

Discussion

Harvey Cushing was the first to intentionally apply hypotension in neural surgery in 1917 in order to reduce bleeding in the operative field. In1946 W.J. Gardner proposed to apply IH for arteriotomy. The method was improved and widely applied in 6-8 decades of the last century (P. Moraka. 1962, S.I. Shaberg, 1976, R. Larsen, 1983, etc.). Later on, with the development of transfusiology and upon emergence of alternative blood retaining methods, the significance of IH reduced, but his method is successfully applied in many areas. Many publications appeared on IH application in maxillofacial surgery (M. Enlund et al, 1997, I. Schindler, 1994, A. Csongrady et al, 1976, R. Chandra et al, 1994, K. Praveen, 2001). Successfully induced hypotension is applied in the middle ear surgery (L. Saarnivaara, P. Brander, 1984, J.M. Marschal et al, 2001, etc.). There are fewer publications on IH application in endoscopic sinus surgery. K.E. Jacobi et al (2001) applied average IH (AABP values – 65-75 mmHg) caused by nitroprusside for endoscopic sinus surgery. Andre P. Boezaartt used nitroprusside and esmolol to develop deep IH (AABP values – 50-60 mmHg) during FESS (1995). Compared to nitroglycerin, nitroprusside is more often opted for to cause IH due to better hemodynamics control. During the research we applied deep IH

caused by nitroglycerin with captopril. Nitroglycerin is more advantageous compared to nitroprusside because of its lower negative impact on perfusion of the most important organs and lower risk of the medication overdose (9). According to sources, when nitroglycerin is used, lower venous bleeding is observed. But application of this medication is limited by a number of shortcomings: longer activity starting time, frequent reflectory tachycardia. When using nitroglycerine the planned arterial blood pressure value is not always achieved (15). Various sources state high resistance to nitroglycerine (16-25%) (13). Looking for ways to improve anesthesia control, we performed a research using captopril. The well-known medication is most often used to treat heart failure and arterial hypertension of easy or medium level. Captopril is the competitive inhibitor of the angiotensin-converting enzyme (ACE). When blocking conversion of the angiotenzine-1 into angiotenzine-2, it disrupts the system of renin, angiotensin and aldosterone. Blood pressure falls down, but the heart rhythm is not reflexively increased. The peripheral blood vessel resistance reduces, but the volume of blood pumped out by the heart does not change obviously. Voodside et al (7) and Jacobi (2), having performed IH with nitroprusside, state that captopril used before anesthesia reduces the need for the vasodilator dosing twice. There is data that ACE inhibitors reduce the dose of nitroglycerine used for IH, as well (14). According to our data the average quantity of nitroglycerine used in the research (0.79±0.34μg/kg/min) is significantly below the recommended by K. Praveen and co-authors (2-8μg/kg/min.) (16). In the hypotensive group in all cases the required AABP was smoothly achieved. We did not observe any reflectory tachycardia. Nitroglycerin infusion activates renin-angiotensin system (7, 8). Angiotenzine-2 counteracts the vasodilating effect of nitroglycerin. Captopril, by suppressing the synthesis of angiotenzine-2, reduces the impact of renin-angiotensin system to hemodynamics. Halothane used during anesthesia, having an inotropic-negative effect, reduced the heart volume per minute – thus potentiating the nitroglycerin blood pressure-reducing effect. We can see that the use of ACE inhibitor in Group H caused lower initial AABP and FHC values in this group, and captopril and halothane mixture during anesthesia caused statistically significant lower FHC values during the entire anesthesia. We did not consider intraoperative bradycardia as a complication of anesthesia; it was 1 time corrected with medications in Group H (FHC<45 t/min). It was proved that upon avoiding tachycardia, myocardium is better supplied with oxygen. It is thought that tachycardia increases bleeding (13). Undoubtedly the risk of kidney and liver ischemia may not be ignored; therefore a major attention was focused on functional preoperative evaluation of these organs. In our case the duration of hypotension observed, efforts to ensure normovolemia allowed to safely perform anesthesia. We think that due to small number of patients examined we received no statistically significantly shorter surgery duration in Group H.

Intraoperative bleeding is subject to several factors: blood system diseases, thrombocyte function, and blood vessel distribution in mucous membrane (2, 6). No doubt, surgical bleeding is influenced not only AABP, but by venous pressure and capillary blood circulation intensiveness, as well. Venous bleeding is reduced by increasing venous blood discharge from the operative field by depositing blood in lower positioned areas. To the opinion of some researchers, capillary bleeding is of the top importance for intraoperative visibility in case of endoscopic sinus surgeries (2). Capillary bleeding is determined by capillary blood circulation intensiveness and by capillary distribution in tissues. Capillary blood circulation may be reduced by lowering arterial blood pressure and by performing local vasoconstriction (6). As far as arterial blood pressure is easy to measure, intraoperative bleeding dependency upon AABP is most often analyzed during IH. Results obtained by us are close to data provided by S. Maune from Kiel University in 1997. Having analyzed 6298 FESS interventions performed in 12 years, authors state that intraoperative hemorrhage reduced by 38%, and the number of hemotransfusions due to intraoperative hemorrhage significantly reduced after staring to apply IH (from 1.7% to 0%) (10). Hemorrhage during FESS is obviously no problem, and hemotransfusion is needed exceptionally rarely (according to data in sources). But there still exists a possibility to transfer blood-spreading infections. At the Rhinology Center no hemotransfusions were performed for patients operated due to accessory nasal sinus pathologies applying IH.

It is thought that the best FESS conditions exist at 2-3 points of operative field quality by Fromme scale (1, 2). As per data of Boezaart and co-authors, good conditions to make FESS were when deep IH (AABP 50-54 mmHg) was caused by both esmolol (2.48 p) and by nitroprusside (3.05 p) (1). To the opinion of authors, better visibility during IH caused by esmolol was due to effect of this medication on arteriole: con-

trary to nitroprusside, esmolol has a vasoconstrictive effect on arteriole. Nitroglycerine we used, especially when used in small doses, dilates more venous capacity vessels, rather than arteriole, and, with the optimum choice of a patient's position, influences development of postural hypotension.

The article analyses efficiency of hypotensive anesthesia application in large-scale endoscopic surgery of accessory nasal sinuses. We used available materials, which are relatively inexpensive. Based on the research results we may state that deep IH caused by nitroglycerine and captopril significantly improved surgical conditions (visibility in the hypotensive group was 2.4 p, without hypotension – 3.4 p). Scientific studies analyzing IH application in FESS arte not multiple, and data provided is sometimes even contradictory. When comparing data by various authors it should not be forgotten that rating of operative field visibility is a subjective criteria. But the majority of authors acknowledge that the visibility is subject to a bleeding rate in the operative field. We observed improvement of the operative field visibility upon reduction of AABP value.

Though all patients examined by us had good tolerance for hypotension, we think that the risk of the method application must never exceed benefits for the patient. Thorough selection of patients, reasonable monitoring and sufficient qualifications of the anesthetist allow avoiding anesthesia complications. IH is the means to achieve the target – lower bleeding, and the anesthetist together with the operating surgeon should make decisions on the necessity to apply the method, having fully evaluated the state of the patient and the planned scope of the surgery before.

Conclusions

1. Induced arterial hypotension caused by captopril and nitroglycerin application during general anesthesia in endoscopic rhinosurgery reduces bleeding and improves the operative field visibility.

2. With thorough selection of patients and reasonable monitoring applied, deep induced arterial hypotension caused by captopril and nitroglycerin does not increase the risk of anesthesia.

Valdomos arterinės hipotenzijos taikymas endoskopinėje rinochirurgijoje

Darius Činčikas, Juozas Ivaškevičius[1]
Vilniaus misionierių ligoninė, Lietuvos rinologijos centras,
[1]Vilniaus universiteto Anesteziologijos ir reanimatologijos katedra

Raktažodžiai: funkcinė endoskopinė sinusų chirurgija, intraoperacinis kraujavimas, valdoma hipotenzija.

Santrauka. Intraoperacinis kraujavimas – viena didžiausių problemų endoskopinėje sinusų chirurgijoje. Vis daugiau ligonių, sergančių nosies ir prienosinių ančių polipoze, operuojama taikant bendrąją anesteziją. Tyrimo tikslas – palyginti intraoperacinį nukraujavimą bei operacinio lauko matomumą normotenzinės ir gilios hipotenzinės, sukeltos nitroglicerinu ir kaptopriliu, anestezijų metu, darant endoskopines prienosinių ančių operacijas. Ištirti 52 ligoniai 1–2 fizinės sveikatos būklės pagal anesteziologų draugijos klasifikaciją: 32 iš jų taikyta valdoma hipotenzija (H grupė), 20 ligonių operacija atlikta normotenzijos sąlygomis (N grupė). Visi ligoniai operacijos išvakarėse premedikuoti diazepamu, H grupės ligoniai operacijos dieną gavo 6,25 mg kaptoprilio. Anestezija atlikta fentaniliu bei halotano garais deguonies ir linksminančių dujų 50:50 proc. mišiniu. H grupės ligoniams arteriniam kraujospūdžiui mažinti vartotas nitroglicerinas. H grupės ligonių vidurinis arterinis kraujospūdis palaikytas 50–60 mmHg. Hipotenzija derinta su operacinio stalo galvūgalio pakėlimu 5 laipsniais. Nukraujavimas matuotas surenkant kraują į sugraduotą siurblį. Operacinio lauko matomumas vertintas pagal Fromme ir Boezaart 5 balų skalę. Statistiškai reikšmingai skyrėsi abiejų grupių ligonių vidurinio arterinio kraujospūdžio bei širdies susitraukimų dažnio rodmenys. Hipotenzinės grupės ligonių nukraujavimas operacijos metu vidutiniškai mažesnis (208 ml) negu normotenzinės grupės (349,2 ml) ($p<0,05$). Operacinio lauko matomumas vidutiniškai vienu balu geresnis hipotenzinės grupės ligonių ($p<0,05$). Tyrimo metu anestezijos sukeltų komplikacijų neužfiksuota. Apibendrinant galima teigti, jog kaptopriliu bei nitroglicerinu sukelta valdoma arterinė hipotenzija reikšmingai sumažino intraoperacinį kraujavimą bei pagerino operacinio lauko matomumą endoskopinėje rinochirurgijoje.

Adresas susirašinėjimui: D. Činčikas, Vilniaus misionierių ligoninė, Subačiaus 26, 2600 Vilnius
El. paštas: dariuscincikas@takas.lt

References

1. Boezaart AP, Merwe J, Coetzee A. Comparison of sodium nitroprusside and esmolol induced controlled hypotension for functional endoscopic sinus surgery. Can J Anaesth 1995;42:373-6.
2. Jacobi KE, Bohm BE, Rickauer AJ, Jacobi C, Hemmerling TM. Moderate controlled hypotension with sodium nitroprusside does not improve surgical conditions or decrease blood loss in endoscopic sinus surgery. J Clin Anesth 2000; 12:202-7.
3. Levine HL, May M. Endoscopic sinus surgery. New York: Thieme Medical Publishers; 1993.
4. Martinkėnas JL, Vaitkus S, Toločka R, Balseris S. Rinosinusitai. (Rhinosinuses.) Vilnius; 1998.
5. Larsen R, Kleinschmidt S. Die kontrollierte Hypotension. Anaesthesist 1995;44:291-308.
6. Simpson P. Perioperative blood loss and its reduction: the role of the anaesthetist. Br J Anaesth 1992;69:498-507.
7. Woodside J Jr, Garner L, Bedford RF, et al. Captopril reduces the dose requirement for sodium nitroprusside-induced hypotension. Anesthesiology 1984;60:413-7.
8. Miller ED, Ackerly JA, Vaughan D, Peach MJ, Epstein RM. The renin-angiotensin system during controlled hypotension with sodium nitroprusside. Anesthesiology 1977;47:257-62.
9. Habler O. Kontrollierte Hypotension. Anaesthesist 2000; 49:687-9.
10. Maune S, Jekstrom W, Thomsen H, Rudert H. Indication, incidence and management of blood transfusion during sinus surgery: a review over 12 years. Rhinology 1997;35:2-5
11. May M, Levine HL, Mester SJ, Schaitkin B. Complications of endoscopic sinus surgery: analysis of 2108 patients. Incidence and prevention. Laryngoscope 1994;104:1080-3.
12. Balseris S, Martinkėnas JL. Funkcinės endoskopinės sinusų chirurgijos komplikacijos. (Complications of functional endoscopic sinus surgery.) Medicinos teorija ir praktika 2000;2:34-7.
13. Mac Rae WR, Wildschmidt JAW, editors. Monographs in anaesthesiology: induced hypotension. Amsterdam; 1991.
14. Rodrigo CH. Induced hypotension during anesthesia, with special reference to orthognathic surgery. Anesth Prog 1995; 42:41-58.
15. Lis VN. Our experience in general anesthesia for endoscopic sinus surgery in cases of extended polyposis. Rossijskaja rinologija 2000;1:13-5.
16. Praveen K, Narayanan V, Muthusekhar MR, Baig MF. Hypotensive anaesthesia and blood loos in orthognathic surgery: a clinical study. Br J Oral Maxill Surg 2001;39:138-40.

Received 25 June 2003, accepted 28 August 2003