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Analysis of the Effectiveness of Neuraxial Anesthesia During Cesarean Section in Patients with Moderate Mitral Stenosis

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Abstract The generally recognized "gold standard" of an anesthesiological manual for abdominal delivery is the use of spinal and epidural anesthesia. At the same time, it should be noted that the above-mentioned pattern is characteristic only of relatively healthy patients with preserved reserve capabilities of the cardiovascular system (CVD) and is unacceptable for many patients with circulatory insufficiency (CNS), due to the real possibility of developing hemodynamic instability. These include pregnant women with "pronounced" mitral stenosis (1.9-1.1 sm2), whose maximum permissible delivery period due to progressive heart failure is 32-34 weeks. The aim of the study is to determine a safe and rational method of regional anesthesia during abdominal delivery in women with moderately pronounced mitral stenosis (valve area 2.0-2.9 cm2) and reduced coronary reserve. The study included 51 patients divided into three groups: spinal anesthesia (I), epidural anesthesia (II), and balanced epidural anesthesia with low concentrations of local anesthetic and fentanyl with preventive analgesia (III). The central and peripheral hemodynamics and functions of the sympathoadrenal and hypothalamic-pituitary systems were assessed. The safest and most effective method was the use of epidural anesthesia with low concentrations of bupivakain in combination with fentanyl and preventive analgesia.

Keywords Spinal anesthesia, Epidural anesthesia, Cesarean section, Mitral stenosis, Coronary reserve

1. Introduction

The choice of anesthesia method for cesarean section in patients with mitral stenosis was carried out taking into account the severity of stenosis and the functional state of the cardiovascular system at the time of delivery, as well as within the timeframes recommended by clinical protocols. Republican Specialized Center of Mother and Child of the Ministry of Health of the Republic of Uzbekistan. The most rational anesthesia method for cesarean section is considered to be central (neuroaxial) blocks (CNB), in particular spinal anesthesia (SA) [1,2,3,10,11]. However, in patients with reduced coronary reserve due to mitral stenosis (MS), their use can lead to pronounced hemodynamic disorders associated with high segmental blockage, as well as a decrease in the adaptive and adaptive capabilities of the cardiovascular system (CVAS). The most problematic group is patients with moderately pronounced MS (valve area 2.0-2.9 cm2), who develop heart failure and hypokinetic circulation regimen at gestational age 34-36 weeks [4,5,6].

Thus, pregnant women with MS of 2.0-2.9 cm2 belong to the high risk group for intra- and postpartum complications and require an individual approach in each specific clinical situation. In this regard, the study of the hemodynamic state in pregnant women with MS using CNS to determine the safest and most acceptable anesthesia method in obstetric practice is of particular importance [7,8,9].

Purpose of the study: to assess the indicators of blood circulation, external respiratory function, as well as the state of the vegetative, sympathoadrenal, and hypothalamic-pituitary-adrenocortical systems at the stages of anesthesia and surgery in pregnant women with moderately pronounced mitral stenosis and reduced adaptive-adaptive capacity of the cardiovascular system, as well as to determine the effectiveness of spinal and various variants of epidural anesthesia during cesarean section.

2. Materials and Methods of Research

The work is based on the results of clinical observations and a complex of clinical, functional, and biochemical studies conducted during cesarean section (CS) in 101 women aged 20-28 at gestational age of 34-36 weeks. All patients had moderately pronounced mitral stenosis (A. N. Okorokov). Progressive heart failure, associated with an increase in gestational age and assessed according to multifactorial criteria for coronary reserve preservation, was an indication

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for early delivery. In all observations, a decrease in the adaptive capabilities of the cardiovascular system was noted. The operations were performed according to plan, their duration was 30-60 minutes.

Depending on the anesthesia method, the patients were divided into three equal groups: Group I (n=17) - spinal anesthesia (SA); II group (n=17) - traditional epidural anesthesia (EA); III group (n =17) - epidural anesthesia with low concentrations of local anesthetic in combination with fentanyl.

Anesthesia in all patients began with premedication: intravenous administration of diphenhydramine (dimedrol) 0.2 mg/kg and dexamethasone 0.07 mg/kg. In group I, a puncture of the subarachnoid space was performed at the level of LII-LIV, followed by the administration of 2.0-2.5 ml (10-12.5 mg) of a 0.5% hyperbaric solution of bupivakaine hydrochloride; the dose was selected individually, taking into account the patient's morphometric characteristics [5,7,8]. In group II, after similar premedication under local infiltrative anesthesia in a side position at the level of ThXII-LIV, puncture and catheterization of the epidural space were performed; the catheter was inserted cranially at 4-5 cm and a test dose of 2 ml of 2% lidocaine hydrochloride solution was administered. In the absence of signs of spinal anesthesia, a 0.5% isobaric solution of bupivakaine hydrochloride was administered fractionally slowly through the catheter at a rate of 1.25-1.5 ml per spinal segment. In group III, the methodology differed in the use of preventive analgesia with paracetamol (1% solution, 100 ml, infulgan) intravenously before puncture and catheterization of the epidural space [4,10,11], as well as the use of a 0.375% solution of bupivakaine hydrochloride in combination with fentanyl (1.4 μg/kg). The operation was initiated when clinical signs of complete segmental motor blockade appeared; patients were given a left-maternal position, the head and middle fragments of the operating table were raised by 10-15 ° (Fovler position). After removing the fetus, diazepam (sibazone) was administered intravenously at 0.2 mg/kg to reduce the psycho-emotional stress.

The effectiveness of anesthesia was assessed based on generally accepted clinical signs. The level of the sensory block was determined by the loss of pain sensitivity using the "pin prick" test, and the upper boundary of the block was fixed after its stabilization. The depth of motor blockade was assessed using the P. Bromage scale. Central hemodynamics was studied by echocardiography on a SA-600 (Medison) apparatus, measuring the stroke index (SI), cardiac index (CI), and total peripheral vascular resistance (TPVS). Average blood pressure (SAB), heart rate (HR), and hemoglobin saturation (SpO2) were monitored using a Schiller monitor [4,9]. Data on the influence of various variants of central neuroaxial blockades on external respiratory function (respiratory rate, respiratory volume, minute respiratory volume, maximum lung ventilation) and gas exchange (SpO2) in patients with moderate mitral stenosis are presented.

The initial preoperative indicators of external respiration and gas exchange function in patients of groups 3, 4, and 5 were identical and did not differ statistically significantly. Moderate hyperventilation (26.0-22.7-23.1 l/min), a decrease in minute lung volume (MVC) to 42.9-43.8 l/min, and a decrease in hemoglobin saturation (SpO2 hemodynamic indicators) were observed. In the preoperative period, the indicators of central hemodynamics in all groups remained within the age norm, however, in patients of groups 3, 4, and 5, a decrease in the cardiac index (CI) and an increase in total peripheral vascular resistance (TPVS) were noted, which reflected compensatory mechanisms in moderately pronounced mitral stenosis.

During anesthesia and after the start of surgery in patients of group I (spinal anesthesia), significant changes in SI and UI were recorded: SI decreased by an average of 18-20%, and UI - by 12-15%, accompanied by a moderate decrease in average blood pressure (SAB) and an increase in heart rate. In patients of group II (traditional epidural anesthesia), the dynamics were smoother: the decrease in CI was 10-12%, CI - 7-9%, and the SAB remained relatively stable. The most stable hemodynamic parameters were observed in patients of group III, where epidural anesthesia with reduced bupivakain concentration in combination with fentanyl and preventive analgesia was used. CI and UI decreased by no more than 5-7%, OPSS remained practically unchanged, average blood pressure fluctuated within 5%, and heart rate remained stable. This dynamic indicates the high effectiveness of the method in maintaining the adaptive and adaptive capabilities of the cardiovascular system in pregnant women with moderately pronounced mitral stenosis up to 92.8-93.1%. These changes differed significantly from the indicators of the 1st and 2nd groups and were primarily due to hemodynamic insufficiency associated with the severity of mitral stenosis.

Before skin incision in all three studied groups, a significant decrease in respiratory rate (RR) of 15.5%, 13% and 11% was recorded, respectively. Respiratory volume (RV) tended to decrease. In patients of the 3rd group, respiratory minute volume (RMV) and MVV significantly decreased by 21.1% and 11.8%, respectively, while SpO2 remained stable (see Table. Changes in DOS, MOD, and MVC in women of groups 4 and 5 were similar in nature, but less pronounced: the absolute values of MOD decreased by 10.7% and 5.9%, and MVC - by 6.5% and 4.2%, respectively.

The above-mentioned changes can be explained by partial blockage of the intercostal nerves, which was more pronounced when using spinal anesthesia. Moderate depression of pulmonary ventilation and respiratory mechanics largely depended on the degree of impairment of hemodynamic parameters. In the most traumatic stages of the operation, the indicators of independent respiration in all three groups did not change significantly compared to the previous stage. A tendency towards an increase in saturation (SpO2) was observed, which is explained by periodic oxygen inhalation during surgery. Respiratory rate increased significantly compared to the previous stage, approaching the initial preoperative values. No clinical signs of respiratory depression were observed. The completion of the operation was

accompanied by a pronounced tendency to normalize the parameters of external respiration and gas exchange function, without significant intergroup differences. An increase in respiratory volume was noted in all three groups compared to the previous stage, which is associated with the restoration of physiological relationships between internal organs and the normalization of intra-abdominal pressure after childbirth. 24 hours after surgery, progressive improvement in ventilation, respiratory mechanics, and gas exchange indicators was observed, which significantly exceeded preoperative values. Respiratory rate in groups 3, 4, and 5 was 20.6±0.5, 19.8±0.3, and 20.1±0.4 per minute; respiratory volume - 0.62±0.03, 0.63±0.04, and 0.61±0.03 l; minute lung volume - 48.8±2.0, 48.1±2.1 and 48.4±1.9 l/min. The SpO2 indicator corresponded to 95.1±1.2-95.3±1.3%.

Thus, the tested variants of central nervous blockade (CNS) do not have a pronounced depressive effect on external respiratory function and gas exchange. At the same time, when using spinal anesthesia (SA), moderate respiratory depression is formed at the height of the segmental sensory-motor block, requiring correction. The adequacy of anesthesia was assessed by the stress index (ST) using a mathematical analysis of heart rhythm, the level of total cortisol (TC) in blood plasma using a radioimmunoassay method, and the rate of norepinephrine (NA) excretion with urine. The studies were conducted in four stages: I - on the operating table; II - before skin incision; III - at the most traumatic stage of the operation (removal of the fetus, revision of the abdominal cavity); IV - after the end of the operation. All numerical indicators were processed using variation statistics methods using Student's t-test using Microsoft Excel and presented as M±m, where M is the arithmetic mean, m is the standard error of the mean, statistically significant differences were considered at $p<0.05$.

3. Results and Discussion

During the characterization of the clinical course of CA in patients of group I: classical signs of a complete segmental sensory-motor block developed by the 6-8th minute after subarachnoid administration of the calculated dose of a local anesthetic and persisted for 1.5-2 hours, the segmental level of sensory blockade corresponded to Th5-Th6. When using variants of epidural anesthesia (EA, II-III groups), signs of complete segmental sensory-motor blockade were formed by the 15-18th minute, the segmental level of sensory blockade corresponded to Th7-Th9, the duration of the surgical stage was 1.5-2 hours.

Throughout the entire operation, including the most traumatic stages, patients of all groups did not complain, no additional anesthesia was required, no signs of respiratory depression were observed, however, the absolute values of SpO2 did not exceed 94-96%, which required periodic oxygen inhalation. The initial hemodynamic parameters in all groups corresponded to the hypodynamic type of blood circulation: pronounced tachycardia, decreased stroke and minute indices, increased total peripheral vascular resistance (TPVS), and minute diuresis was within the lower limits of the physiological norm. No intergroup differences were recorded in these initial indicators. Against the background of CNS, pronounced but physiologically limited activation of the sympathetic section of the VNS (CI 336.4±20.6-349.4±35.7 conv. units) was noted, an increase in the concentration of CD in blood plasma and NA in urine compared to patients with a normal pregnancy at 34-36 weeks, while no significant intergroup differences were found. Before the skin incision, against the background of a complete segmental block, all groups experienced a decrease in heart rate, a decrease in mean dynamic pressure (MSBP), and a more pronounced decrease in OPSP in CA: in group I, MSBP and OPSP decreased by 28.9% and 17.2%, heart rate by 11.4%, respectively, which required vasopressor support, and the cardiac index (CI) decreased from 2.43±0.04 to 1.97±0.06 l/m2/min. In patients of group II, the decrease in DSD and OPSS was 16.4% and 10.3%, the HR decreased by 6.4%, and the SI decreased by 2.28±0.09 l/m2/min. In group III, hemodynamic changes were minimal: DSD and OPS decreased by 9.1% and 4.8%, heart rate decreased by 2.7%, SI was 2.72±0.09 l/m2/min. Subsequently, in the traumatic stage and at the end of the operation, hemodynamic parameters gradually normalized, while statistically significant improvement in minute diuresis and maintenance of SI within physiological norms was noted. It should be noted that vasopressor support was required: in the 1st group of patients - 100% of observations; in the 2nd group - 6 women (42.8%); in the 3rd group - only 2 women (11.7%). Immediately before the operation, against the background of complete segmental sensory-motor and sympathetic blockade, patients of the 1st group recorded a significant decrease in the tension index (TBI) by 31.8%, which indicated a significant decrease in sympathetic influences and the degree of tension in the heart rhythm regulatory systems. At the same time, the concentration of total cortisol (TC) in blood plasma increased by 53.1%, which is due to the adequate protective reaction of the hypothalamic-pituitary-adrenal system to the restructuring of hemodynamics and the reduction of sympathetic influences. In patients of the II and III groups, the IN had only a tendency to decrease and amounted to 298.2±20.2 and 302.1±20.5 units, respectively. The concentration of SC in blood plasma significantly increased by 42% (II group) and 33.5% (III group). In the most traumatic stages of surgery, no significant changes in the studied hemodynamic parameters were observed compared to the previous stage. The most pronounced shifts were observed in the 1st group, where spinal anesthesia (SA) was used, while minimal hemodynamic disturbances were noted in the 3rd group, where epidural anesthesia was used. IN in all three groups significantly increased compared to the initial preoperative values and the previous stage of the study, comprising: I-group - 446.4±21.6 conv. units, II-group - 450.2±23.4 conv. units, III-group - 490.8±24.3 conv. units. Correspondingly, the concentration of SC in blood plasma increased: I-group - 743.3±38.4 nmol/l, II-group - 687.2±36.1 nmol/l, III-group - 677.6±37.4

nmol/l. It should be noted that in none of the groups, the studied parameters did not exceed the "stress-norm," which confirms the adequacy of anesthesia. The end of the operation in all patients was accompanied by a tendency towards normalization of hemodynamic parameters, however, the hypodynamic blood circulation regime persisted. A significant increase in minute diuresis and a decrease in heart rate were observed compared to the previous stage. The cardiac index (CI) in patients of groups II and III did not differ from the values before birth. In patients of the 1st group, the indicators of DSD, SI, and minute diuresis remained significantly lower: 76.4±1.6 mm Hg, 2.21±0.05 l/m2/min, and 0.42±0.03 ml/min, respectively. At the end of the operation, moderate tension in the heart rhythm regulatory systems was maintained. IR exceeded the preoperative absolute values: I-group - by 23.6%, II-group - by 17.4%, III-group - by 16.8%. The concentration of CK in blood plasma decreased moderately, but did not differ significantly from the previous stage. The excretion of noradrenaline (NA) with urine during the operation period increased compared to the initial values: I-group - by 13.1±1.1 nmol/l, II-group - by 12.5±1.3 nmol/l, III-group - by 12.3±1.3 nmol/l. On the operating table, the initial IR indicators in patients of all three groups were within normal limits and did not differ significantly: 336.4±20.6 conv. units. (Group I), 349.6±18.6 conv. units. (II group) and 339.4±23.1 conv. units. (III group), which reflects the relative balance of sympathetic and parasympathetic activity before anesthesia begins. Before the skin incision, against the background of a complete segmental sensory-motor blockade, a significant decrease in BMI to 229.4±20.8 conditioned units was observed in patients of group I. (Δ, $p<0.05$), which indicated a significant suppression of sympathetic activity and a decrease in the degree of tension of the heart rhythm regulatory systems. In groups II and III, the tension index had only a tendency to decrease: 289.2±20.2 and 302.1±20.5, respectively, which indicates a milder effect of epidural anesthesia on the autonomic system. The concentration of total cortisol (TC) in blood plasma increased significantly in all groups, however, the greatest increase was noted in group I (628.2±26.1 nmol/l, *$p<0.05$ compared to the baseline level and group III), which is associated with the compensatory activation of the hypothalamic-pituitary -adrenocortical system against the background of decreased sympathetic activity. In groups II and III, the increase in SC was 582.7±32.5 and 521.4±30.8 nmol/l, which reflects a more moderate stress response. In the most traumatic stage of the operation (removal of the fetus, revision of the abdominal cavity), a significant increase in blood pressure was observed in all groups compared to the previous stage: 446.4±21.6 (I group), 450.2±23.4 (II group) and 490.8±24.3 units. (III group), which was accompanied by an increase in SC concentration, reaching 734.3±38.4, 687.2±36.1, and 677.6±37.4 nmol/l, respectively. These data indicate an adequate stress-adaptive response of the body to surgical trauma under conditions of effective anesthesia. Summarizing the data obtained, it can be concluded that among the variants of central neuroaxial blockade (CNAB) used by us, the greatest antinoceptive effectiveness is demonstrated by epidural anesthesia using reduced concentrations of bupivakain in combination with fentanyl. This method is characterized by minimal negative impact on the main life support systems, making it the most acceptable in terms of safety for pregnant women with moderately pronounced mitral insufficiency and limited coronary reserve.

4. Conclusions

The most appropriate method of anesthesiological support for cesarean section in patients with moderately pronounced mitral insufficiency and reduced coronary reserves at gestational age of 34-36 weeks should be recognized as balanced epidural anesthesia using 0.375% bupivakain solution in combination with fentanyl at a dose of 1.4 μg/kg and preventive analgesia with 100 ml of 1% paracetamol solution. The method used is highly effective, has minimal impact on central hemodynamics, and provides the possibility of continuous postoperative anesthesia.

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