

Efficacy of Combined Anesthesia Based on Epidural Blockade in Cesarean Section for Women with Mitral Stenosis

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Abstract Objective: This study aims to assess the effectiveness of combined anesthesia utilizing epidural blockade during cesarean section procedures in women diagnosed with mitral stenosis. Materials and Methods: The research is grounded in clinical observations and a comprehensive analysis of clinical, functional, and biochemical data obtained during cesarean sections in 26 women aged 18-30, at gestational ages of 32-34 weeks. All participants presented with "severe" mitral stenosis according to the classification by A.N. Okorokov. Two groups were formed based on the method of anesthesia: the first group underwent combined anesthesia (CA) relying on epidural blockade (EB), while the second group received one of the common forms of general multicomponent anesthesia (GMA with MV). The study evaluated hemodynamic status, anesthetic efficiency, and postoperative outcomes. Results: The CA based on EB demonstrated significant advantages, including minimal consumption of general anesthetics and muscle relaxants, prompt restoration of reflex-muscular activity facilitating early tracheal extubation, and the potential for postoperative epidural catheter utilization for extended analgesia. The study highlights the superiority of CA based on EB over traditional GMA with MV. Conclusion: CA based on epidural blockade ensures reliable antinociceptive protection against surgical aggression, resulting in smooth anesthesia progression and immediate postoperative recovery. This method presents a clear advantage over the conventional GMA with MV approach.

Keywords Cesarean section, "Severe" mitral stenosis, Combined anesthesia based on epidural blockade, General multicomponent anesthesia

1. Introduction

In the realm of abdominal deliveries, spinal and epidural anesthesia are widely acknowledged as the "gold standard" for anesthetic management, particularly in obstetrics [1-4]. These methods are generally considered safe, as they do not impact the upper segments of the spinal cord above the Th6-Th7 level, thereby preserving adequate vasopressor response despite segmental denervation at lower levels.

It's crucial, however, to recognize that this standard applies predominantly to patients with a healthy cardiovascular system. This approach may not be suitable for patients with circulatory insufficiency, including pregnant women with significant conditions like severe mitral stenosis, where heart function is compromised. These patients, especially those with a mitral valve area ranging between 1.9 and 1.1 cm², often face limitations in their gestational period (32-34 weeks) due to escalating heart failure risks [5-12].

For these high-risk groups, general anesthesia with mechanical ventilation (MV) often becomes the preferred analgesic method, diverging from the usual reliance on spinal-epidural techniques [4,13-15]. This shift necessitates a detailed examination of hemodynamic responses in pregnant women with severe mitral stenosis undergoing different anesthetic approaches, namely traditional general multicomponent anesthesia (GMA) and a combined anesthesia (CA) approach that incorporates epidural blockade (EB). The primary objective of this study is to evaluate and compare these anesthetic methods in terms of safety and effectiveness, specifically tailored for obstetric practice involving high-risk cardiac conditions.

2. Main Body

Objective: To evaluate the hemodynamic status and anesthetic effectiveness of combined anesthesia (CA) in pregnant women with "severe" mitral stenosis (MS), significantly reduced coronary reserves, and circulatory insufficiency (CI).

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2.1. Materials and Methods

The study is based on the results of clinical observations and a complex of clinical, functional, and biochemical studies during cesarean section in 26 women aged 18-30 years at gestational ages of 32-34 weeks. All patients had "severe" mitral stenosis (according to the classification by A.N. Okorokov) [8].

According to multifactorial criteria assessing the preservation of coronary reserves in all 26 observations, the adaptive-adaptive capabilities of the cardiovascular

system (CVS) were significantly reduced [7,8,11,15]. The operations were planned, with a duration of 35-60 minutes, and the anesthesia duration was 50-80 minutes. Depending on the method of analgesia, all patients were divided into 2 equal groups. Patients in the 1st group (n=13) underwent surgery under combined anesthesia (CA) based on epidural blockade (EB), while patients in the 2nd group (n=13) underwent surgery under one of the most common variants of general multicomponent anesthesia (GMA with MV) (shown in Figure 1).

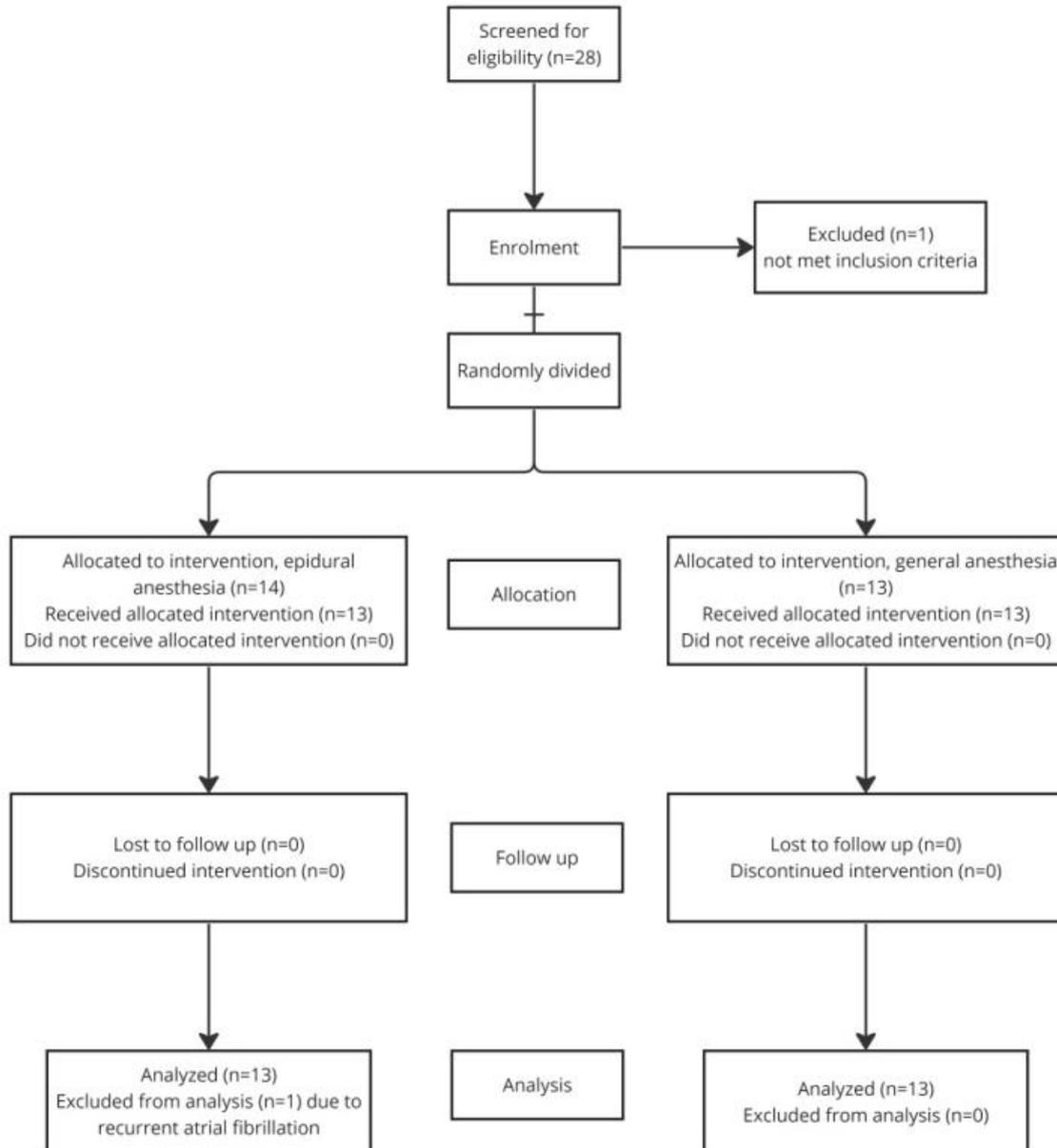


Figure 1. Consort diagram

The CA based on EB method included the following steps: after intramuscular injection of diphenhydramine (0.2 mg/kg), dexamethasone (4-8 mg), and intravenous administration of paracetamol (100 ml of 1% solution) [2], a puncture-catheterization of the epidural space was

performed at the L2-Th12 level. The catheter was inserted cranially by 4-5 cm with subsequent administration of a "test dose" (2 ml of 2% lidocaine). In the absence of signs of spinal blockade, a 0.25% solution of bupivacaine hydrochloride in a volume of 14-16 ml was fractionally

slowly introduced through the epidural catheter, combined with 1.4 mcg/kg of fentanyl. With the appearance of the first signs of segmental sensory-motor blockade, induction of anesthesia (ketamine 1-1.5 mg/kg), precurarization (1 mg of Arduan), and dithylin (2 mg/kg) were performed, followed by tracheal intubation. Before intubation, the vocal cords were treated with 10% lidocaine aerosol, and 1.4 mcg/kg of fentanyl was administered. Mechanical ventilation was performed in a mode of moderate hyperventilation using a nitrous oxide-oxygen mixture (2:1). Total curarization was achieved with Arduan (2 mg). The operation began with the appearance of clinical signs of segmental sensory-motor blockade. Patients were placed in the "left uterine" position, and the head and middle segment of the operating table were raised by 10-15° (Fowler's position). Due to the use of 0.25% solution of bupivacaine hydrochloride for epidural anesthesia, there was no need for the repeated administration of the drug and drugs for general anesthesia during the intraoperative period.

Tracheal extubation was performed only after the full restoration of reflex-muscular activity, consciousness, adequate spontaneous breathing, against the background of stable hemodynamics, and fully compensated blood loss. Medication decurarization was not used, preferring spontaneous decurarization.

Infusion-transfusion therapy was strictly limited, but intraoperative blood loss was compensated mainly with crystalloid preparations at a rate of 5-8 ml/kg.

Postoperative analgesia was carried out through the epidural catheter using predominantly a 2% lidocaine solution.

GMA with MV method: Among the various options for GMA with MV, we chose the most commonly used in operative obstetrics for pregnant women with circulatory insufficiency [4,12,15]. Premedication included diphenhydramine (0.2-0.3 mg/kg), dexamethasone (4-8 mg), and cardiac glycosides. Anesthesia induction was performed with ketamine (1.5 mg/kg) and fentanyl (1-1.5 mcg/kg). After precurarization with Arduan or pancuronium (1 mg), dithylin (1.5-2 mg/kg) was administered, and with the appearance of clinical signs of total curarization, tracheal intubation was performed, and patients were transferred to MV in a mode of moderate hyperventilation. Anesthesia maintenance until the extraction of the fetus was achieved with a nitrous oxide-oxygen mixture (2:1; 1:1). Immediately after the extraction of the fetus and clamping of the umbilical cord, anesthesia was deepened by introducing fentanyl (loading dose of 3 mcg/kg; maintenance dose of 5 mcg/kg/h) and sibazon (0.14 mg/kg every 45-60 minutes). Inhalation of the N₂O:O₂ mixture (1:1) was continued. Otherwise, the intraoperative management method did not differ from the 1st group of patients.

Postoperative analgesia was performed in the traditional way using narcotic and non-narcotic analgesics.

Regardless of the method of analgesia, all operated patients were transferred to the intensive care unit, where appropriate syndrome therapy and round-the-clock monitoring of vital systems were carried out.

The effectiveness of analgesia was judged by generally accepted clinical signs. The level of the sensory block was assessed by loss of pain sensitivity (pin-prick test). To assess the depth of motor blockade, the P. Bromage scale was used. Central hemodynamics were studied by echocardiography using the SA-600 apparatus from "Medison." Stroke index (SI), cardiac index (CI), total peripheral vascular resistance (TPVR), mean dynamic pressure (MDP), heart rate (HR), and hemoglobin saturation (SpO₂) were monitored using monitors MP6-03-"Triton" (Russia) and Mindray (China). Anesthesia adequacy was assessed by the tension index (TI) using mathematical analysis of heart rate [3], the level of total cortisol (TC) in the blood plasma (radioimmunoassay method), and the rate of norepinephrine (NE) excretion in urine [6]. Studies were conducted at 5 stages: 1 – on the operating table; 2 – before skin incision; 3 – revision of the abdominal cavity after fetus extraction (the most traumatic stage of the operation); 4 – after the end of the operation; 5 – 24 hours after the operation. All numerical values obtained during the study were processed using variation statistics methods with the use of the Student's t-test (using the Microsoft Excel program) and presented as $M \pm m$, where M is the arithmetic mean, and m is the standard error of the mean. Differences were considered statistically significant at $p < 0.05$. The obtained results are presented in the table. An easy way to comply with the paper formatting requirements of SAP is to use this document as a template and simply type your text into it.

2.2. Results and Discussion

The initial baseline parameters characterizing the functional state of the cardiovascular system (CVS) in pregnant women from both investigated groups were identical and corresponded to II-III functional class (FC) of circulatory insufficiency (CI) according to NYHA. All observed patients exhibited a hypokinetic mode of circulation, along with pronounced tachycardia (see table). Against this background, a sufficiently pronounced activation of the sympathetic division of the autonomic nervous system (ANS) was recorded, but it did not exceed the limits of physiological fluctuations (IN ranged from 415.4 ± 30.8 to 426.2 ± 32.4 arbitrary units). The predominance of sympathetic activity in the autonomic balance is associated with pregnancy and a significant decrease in coronary reserves, which negatively influences the essential life support systems for parturients.

The concentration of cortisol (SK) in plasma and norepinephrine (NA) in urine was also elevated compared to those in patients with normally progressing pregnancies at 32-34 weeks. No significant intergroup differences were registered for the studied parameters. Before the skin incision following tracheal intubation and transferring patients to mechanical ventilation (MV), patients in the second investigated group exhibited a significant increase in systolic duration dispersion (Sdd) and systemic vascular resistance index (SVRI) by 6% and 8.3%, respectively. A decrease in minute diuresis to 0.26 ± 0.01 ml/min and a tendency to increased heart rate (HR) and decreased stroke

volume index (SVI) were also noted. This could be explained by the adequate pressor response of the CVS to tracheal intubation and the associated brief hypoxia.

During the same period, patients in the first group showed a significant decrease in HR by 8.7%, a tendency to reduce Sdd, a significant relative to the previous stage of the study decrease in SVRI by 16.3%, and a slower rate of decrease in minute diuresis compared to the second group (see table).

Overall, positive changes in hemodynamics in patients of the first group can be interpreted as a result of preventive analgesia, preoperative spraying of the vocal cords with 10% lidocaine aerosol, and moderately pronounced segmental sympathetic blockade.

This stage of the study in patients from both groups was accompanied by tension in the regulatory systems of cardiac rhythm, an increase in the concentration of total cortisol (SK) in plasma, significantly more pronounced in patients of the second group (see table).

Results and Discussion:

At the most traumatic stage of the operation, there were no significant changes in the studied hemodynamic parameters in both investigated groups compared to the previous study. The most significant shifts continued to be observed in the second group of patients who underwent general anesthesia (GA) with mechanical ventilation (MV), while minimal hemodynamic disturbances were recorded in the first group

when using epidural block (EB) with reduced concentrations of local anesthetics (see table). Thus, in the first group, patients showed a tendency toward a decrease in systolic duration dispersion (Sdd) and systemic vascular resistance index (SVRI), amounting to 79.6±2.1 mmHg and 1843.4±64.1 dyn·s·cm⁻⁵, respectively. Heart rate (HR), cardiac index (CI), and minute diuresis remained without significant dynamics.

During the same period, patients in the second group had significantly higher Sdd and SVRI, measuring 92.3±2.6 mmHg and 2480.3±80.6 dyn·s·cm⁻⁵, respectively. CI was 1.86±0.09 L/m²/min, and minute diuresis was 0.28 ml/min.

The tension index (IN) significantly increased in both investigated groups compared to baseline preoperative values and the previous stage of the study, reaching 846.8±38.4 arbitrary units in the first group and 1168.2±36.9 arbitrary units in the second. Correspondingly, the concentration of cortisol (SK) in plasma increased, reaching 769.2±29.4 nmol/L in the first group and 926.3±32.8 nmol/L in the second. Significant differences in parameters characterizing the functional state of the sympathetic division of the autonomic nervous system, the degree of tension in the regulatory systems of cardiac rhythm, and the activation of the hypothalamo-pituitary-adrenal system indicate a more effective antinociceptive protection against surgical and anesthesiological aggression when using epidural analgesia (EA), the main component of which is EB with reduced concentrations of local anesthetics (see table).

Table 1. Some indicators of central hemodynamics, sympathoadrenal, and hypothalamo-pituitary-adrenocortical system in patients of the main and control groups (1st and 2nd groups)

Studied parameters.	Groups.	Stages of the study.				
		1	2	3	4	5
HR, beats per minute	1	109,1±2,4	99,6±2,1®	101,4±1,6®	96,4±1,3	98,5±1,4®
	2	108,6±2,2	112,4±3,1	110,6±71,9	103,3±1,2	105,3±1,6
Systolic Duration Dispersion (Sdd), mmHg	1	84,8±1,9	80,2±2,2	79,3±2,1	80,4±2,4	80,1±2,6
	2	86,4±1,6	91,6±1,3®	92,3±2,6	86,8±2,1	84,3±2,8
Cardiac Index (CI), L/m ² /min	1	2,09±0,09	2,18±0,06	2,15±0,1	2,19±0,06	2,02±0,09
	2	2,1±0,1	1,95±0,07	1,86±0,09®	2,16±0,09Δ	2,06±0,1
Systemic Vascular Resistance Index (SVRI), dyn·s·cm ⁻⁵	1	2196,3±72,6	1839,6±70,6®	1843,4±64,1	1836,1±56,2®	1982,1±68,1®
	2	2168,8±59,6	2348,1±54,9®	2480,3±80,6	2008,7±34,3Δ	2045,2±73,4
Minute Diuresis, ml/min	1	0,46±0,01	0,34±0,01®	0,32±0,02®	0,51±0,02®Δ	0,54±0,03®
	2	0,47±0,02	0,26±0,01®	0,28±0,03®	0,34±0,01®Δ	0,48±0,02Δ
Cortisol (SK), nmol/L	1	544,2±41,3	703,4® ±36,2	769,2±29,4®	732,8® ±31,6	602,1±31,8®Δ
	2	552,3±44,1	883,9® ±40,4	926,3® ±32,6®	802,4®±30,2Δ	604,3±30,4®Δ
Tension Index (IN), arbitrary units	1	415,4±30,8	662,4® ±36,4	846,8®Δ±38,4®	744,6®±41,1Δ	622,6±40,1®Δ
	2	426,2±32,4	960,9® ±30,8	1168,2®Δ±36,0	822,6±40,4®Δ	632,4±38,6®Δ
Norepinephrine (NA), nmol/L	1	10,2±1,1	-	-	14,3® ±0,8	-
	2	9,6±0,9	-	-	18,6±1,1®	-

Note: ® - significance of differences (P<0.05) compared to baseline values; Δ - significance of differences (P<0.05) compared to the previous stage of the study; □ - significance of differences (P<0.05) between the 1st and 2nd groups.

The conclusion of the operation in patients from both investigated groups was accompanied by a tendency toward normalization of the studied hemodynamic parameters without significant intergroup differences (see table). Exceptions were SVRI and minute diuresis, the degree of normalization of which was significantly more pronounced in patients of the first group. Thus, in the first group of women, SVRI and minute diuresis were $1836.1 \pm 56.7 \text{ dyn s cm}^{-5}$ and $0.51 \pm 0.07 \text{ ml/min}$, respectively, while in the second group, they were $2008.7 \pm 64.3 \text{ dyn s cm}^{-5}$ and $0.34 \pm 0.01 \text{ ml/min}$, indicating persistent peripheral vascular spasm in patients of the second group.

By this point in both investigated groups, there was a decrease in sympathetic influences and the degree of tension in the sympathoadrenal and hypothalamo-pituitary-adrenocortical systems (see table). However, these indicators remained at sufficiently high levels, indicating an adequate response of the body to surgical trauma. The norepinephrine (NE) excretion with urine during the operation period in the second group of patients was $18.6 \pm 1.1 \text{ nmol/L}$, while in the first group, it was significantly less pronounced, measuring $14.3 \pm 0.8 \text{ nmol/L}$, which also indicates a higher effectiveness of epidural analgesia (EA) based on reduced concentrations of bupivacaine hydrochloride.

Twenty-four hours after the end of the operation, patients in both the first and second groups showed a tendency towards an increased heart rate (HR), a decrease in stroke volume and cardiac output, and an elevation in systemic vascular resistance index (SVRI) compared to the previous stage of the study (see table). The hypokinetic mode of circulation persisted. At the same time, plasma cortisol (SK) and the tension index (IN) significantly decreased, measuring $602.1 \pm 31.8 \text{ nmol/L}$ and 622.6 ± 40.1 arbitrary units, respectively, in the first group, and $604.3 \pm 30.4 \text{ nmol/L}$ and 632 ± 38.6 arbitrary units, respectively, in the second group, significantly exceeding the initial preoperative values (see table). This indicates the preservation of a stressful situation, both due to the presence of severe atrioventricular stenosis provoking circulatory insufficiency and the trauma from the surgery.

A comparative analysis of the anesthesia course in the immediate postoperative period in patients of the first and second groups revealed significant advantages of epidural analgesia (EA): minimal drug consumption for general anesthesia and muscle relaxants, rapid restoration of reflex-muscular activity allowing earlier extubation, and the possibility of using an epidural catheter for prolonged postoperative analgesia.

The obtained data allow us to assert that epidural analgesia (EA) provides reliable antinociceptive protection against surgical aggression, ensuring a smooth course of anesthesia and the immediate postoperative period, thus having a clear advantage over the traditional option of general anesthesia (GA) with mechanical ventilation (MV).

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2.3. Statistical Methods Description

Statistical analysis was performed using SPSS. We employed descriptive statistics to summarize the data and inferential statistics to test hypotheses. Data were cleaned for inconsistencies and missing values were managed by listwise deletion. To compare our groups, we used t-tests/ANOVA for continuous variables and chi-square tests for categorical variables, as appropriate. The significance level was set at $p < 0.05$ for all tests. We checked for normality and homogeneity of variance assumptions where applicable.

3. Conclusions

1. The use of epidural analgesia (EA) based on epidural block (EB) is justified for providing anesthesia during cesarean section in patients with "pronounced" mitral stenosis (MS).
2. The tested variant of epidural analgesia (EA) based on epidural block (EB) ensures reliable antinociceptive protection against surgical aggression, hemodynamic stability, and a smooth course of the immediate postoperative period.

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