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Aortic Valve Replacement through Median Sternotomy and Ministernotomy: A Comparison of the Results

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VILNIAUS UNIVERSITETAS

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Vidurinės sternotomijos ir ministernotomijos aortos vožtuvo keitimo operacijų rezultatų palyginimas.

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ABBREVIATIONS

BMI – body mass index

CABG – coronary artery bypass grafting

CI – confidence interval

ECHO – echocardiography

ECMO – extracorporeal membrane oxygenation

FFP – fresh frozen plasma

HFFC – heart failure functional class

INR – international normalized ratio

ISTD – interventricular septum thickness in diastole at rest, cm

LV – left ventricle of the heart

LVDD – diameter of the left ventricle in diastole, cm

LVEF – left ventricular ejection fraction

LVSD – diameter of the left ventricle in systole, cm

MI – minimal invasion

NYHA – New York Heart Association Functional Classification

OR – odds ratio

PG max – maximum gradient on aortic valve

PG mean – mean gradient on aortic valve

VAC – Vacuum-Assisted Closure

VAS – visual analogue scale

WA – weighted average (mean)

ECMO – Extracorporeal membrane oxygenation

IABP – Intra-aortic balloon pump

INTRODUCTION

Relevance of the problem

Over the past decade, the frequency of the aortic valve pathology has increased enormously, which has led to a search for sparing methods of surgical treatment. As a result, in 1996, new, minimally invasive approaches appeared in the arsenal of surgeons (upper and lower ministernotomy, V-shaped, Z-shaped, T-shaped, J-shaped and other types of ministernotomies). The development of new methods has allowed for improving the results of treatment and reducing the incidence of complications compared with median sternotomy; however, the question of their advantage over the traditional median sternotomy is still open.

It is known that the "gold standard" of aortic valve replacement by median sternotomy in the conditions of artificial circulation certainly gives better access to the heart, but at the same time, it is associated with greater traumatism, a risk of bleeding and a subsequent development of mediastenitis. In addition, severe pain syndrome in the early postoperative period requires the repeated use of narcotic analgesics even after discharge of patients and may contribute to an onset of respiratory failure due to the violation of breathing mechanics. In contrast, it has been proved that minimally invasive approaches reduce blood loss, decrease the likelihood of infection and the duration of hospitalization, improve the cosmetic effect and accelerate patient recovery.

However, some authors, in addition to the positive aspects of ministernotomy, emphasize its shortcomings – such as the longer operative duration, longer period of aortic cross-clamping with the transverse clamp and artificial circulation. These aspects are particularly relevant for patients at risk, in whom they can significantly affect the results of the operation and the subsequent well-being of the patient.

There is an opinion that with the accumulation of surgical experience, all of the abovementioned problems can be solved, and that ministernotomy results will become better, providing the possibility of expanding the indications for the application of minimally invasive methods. Therefore, the experience of each individual clinic is of interest.

It should be noted that the choice of optimal access is not only medical, but also socioeconomic in nature, since specific complications arising after operations significantly worsen treatment results and often lead to a persistent disability of the patients, and their treatment requires additional financial costs.

IMPORTANCE AND NOVELTY OF THE RESEARCH

Despite the fact that there are many studies comparing the results of median sternotomy and minimally invasive techniques to date, all of them are mainly concerned with surgical nuances. At the same time, studies regarding the need for medications, investigations of postoperative course features and the restoration of physiological functions in two groups of patients have not been given due attention. In addition, modern studies focus on short-term results, but the effect of the method of performing the operation on long-term outcomes and patient survival cannot be excluded either, and this requires further study as well. Thus, it is necessary to carry out the detailing of the available results by conducting a detailed comparison of operations by means of ministernotomy and median access, revealing not only features of the course of operation itself, but all the subtleties of the postoperative period and the period of long-time observation.

In addition, the peculiarity of works available to date is that most of them are studying individual aspects of treatment results, such as the course of operation, early postoperative results or long-term results.

At the same time, there is a need for an integrated study that considers all these factors, as it would be a comprehensive study of an issue that would determine the global advantages of a particular technique.

The innovative value of this work lies in that it is a comprehensive study of all possible influences of the type of access on the patient's health.

The results of the work detail the course of operation and the early postoperative period in patients undergoing ministernotomy and median access. We have studied not only the generally accepted characteristics but also the needs in various groups of drugs, the courses of the recovery period and the subjective feelings of the patient.

This study presents the most complete dynamic assessment of the clinical characteristics and echocardiography indicators for a duration of 3 years, which characterizes the functional state of the patients' cardiovascular systems and their overall well-being, and this significantly complements the results of other studies that did not disclose the detailed course of the postoperative period in these patients.

Another important aspect is the need for the correction of indications for performing access, since with the accumulation of technical experience, there is a change in the principles of patient selection for carrying out one or the other type of intervention. This is especially clearly seen in the example of patients at risk. Particularly in the case of patients with obesity, we see that

not so long ago, overweight was considered a contraindication for the implementation of minimally invasive interventions. However, recently, a rethinking of these views has occurred, and studies have appeared that show that the use of ministernotomy is associated with a smaller volume of operational trauma, a reduction in the number of postoperative complications and a faster recovery of patients. Thus, it is necessary to develop new principles for the selection of patients for ministernotomy. However, information about the long-term results of surgical interventions also remains very scarce and requires additional research.

As part of the development of such a strategy of selecting patients as a basis, it is important to study the effects of anthropometric, clinical and laboratory indicators before surgery on the course of surgical intervention and on the course of the nearest postoperative period in patients when using various techniques, especially since such studies are single.

By means of a correlation analysis, the effect of preoperative indices on the course of surgical intervention and on the course of the nearest postoperative period in patients after ministernotomy and median access was assessed, which can serve as a basis for new criteria for choosing a particular type of operation depending on the patient's initial characteristics.

Thus, a detailed comparison of operation results, including the short- and long-time results of mini-invasive and traditional methods, is quite relevant for selecting the most prioritized type of access.

THE AIM OF THE RESEARCH

The purpose of this study is to compare the results of aortic valve replacement by means of median sternotomy and minimal invasion (ministernotomy).

THE OBJECTIVES OF THE RESEARCH

1. An assessment of the effectiveness and safety of the ministernotomic approach when replacing an aortic valve in patients suffering from aortic valve pathology and its comparison with the median (standard) sternotomic approach.

2. A comparative analysis of the operative peculiarities of aortic valve replacement in patients from groups when applying the ministernotomic and median sternotomic approaches.

3. A comparative analysis of the postoperative indices in patients from groups who have received ministernotomy and sternotomy treatments when assessing the indices during the patients' stays in an intensive care unit.

4. A study of the early postoperative clinical results in patients from comparative groups, including the rate of complications, sensations of pain, the ability to perform simple actions and the length of hospital stays.

5. A study of long-term clinical results in patients from comparative groups.

6. An assessment of the impact of anthropometric, clinical and laboratory indices in patients who underwent preoperative examinations on the process of surgical intervention and the peculiarities of the early postoperative period when applying the minimum and median sternotomic approaches.

7. A comparative analysis of characteristics in patients who are overweight after surgery for aortic valve replacement when applying the minimal and median sternotomic approaches, and an assessment of early and long-term results in patients from both groups.

8. An assessment of what impact does overweight have on the operative and postoperative results in patients from both groups in question.

SCIENTIFIC NOVELTY

The innovative value of this work lies in that it is a comprehensive study of all possible influences of the type of access on the patient's health.

The results of the work detail the course of operation and the early postoperative period in patients undergoing ministernotomy and median access. We have studied not only the generally accepted characteristics but also the needs in various groups of drugs, the courses of the recovery period and the subjective feelings of the patient.

This study presents the most complete dynamic assessment of the clinical characteristics and echocardiography indicators for a duration of 3 years, which characterizes the functional state of the patients' cardiovascular systems and their overall well-being, and this significantly complements the results of other studies that did not disclose the detailed course of the postoperative period in these patients.

By means of correlation analysis, the effect of preoperative indices on the course of surgical intervention and on the course of the nearest postoperative period in patients after ministernotomy and median access was assessed, which can serve as a basis for new criteria for choosing a particular type of operation depending on the patient's initial characteristics.

PRACTICAL SIGNIFICANCE OF THE RESEARCH

The practical significance of this study lies in the possibility of using the results obtained in the work of cardiac and cardiosurgical departments and centers to optimize the treatment of

patients with aortic valve pathology, to reduce surgical lethality and to shorten the period of hospitalization.

As a result of the work done, the main problems in the early and distant period were identified in patients who had undergone median sternotomy and ministernotomy. A more sparing effect of ministernotomy is noted, which makes it possible to recommend this access as a priority intervention in the case of aortic valve pathology.

A clarification of the criteria for choosing a particular type of operation, depending on the patient's initial characteristics, makes it possible to expand the indications for ministernotomy.

It is proved that ministernotomy not only accelerates the patient's return to everyday life but also contributes to more favorable clinical results and probably has a higher economic efficiency due to the shorter duration of hospitalization and the use of fewer medicines.

1. Subjects and Methods of the Research

1.1 Research Subjects

This is a retrospective study of patients who underwent isolated aortic valve replacements by means of either median sternotomy or ministernotomy during 2011–2016 on the base of Vilnius University Hospital Santaros Klinikos. In order to conduct the study, Permission No. 158200-14-715-235 was obtained from the Vilnius Regional Committee for the Ethics of Biomedical Research. A total of 426 patients, aged from 18 to 88 years with isolated aortic valve pathologies, were examined. Seventy of the patients underwent mininsternotomies, and 356 patients underwent median sternotomies. Data were collected from medical case histories, surgical and anesthesia protocols and outpatient cards.

At the first stage of the research, two groups, each consisting of 70 patients, matched for age, sex, body mass index, primary diagnosis, disease etiology, NYHA score and echocardiography parameters before surgery, were selected using the method of propensity score matching (PSM).

The first (main) group included patients who had undergone aortic valve replacement by means of a ministernotomy. **The second group (control group)** consisted of patients who had undergone median sternotomy.

The second phase of the research was devoted to an analysis of the results of interventions to replace the aortic valve in patients who were overweight. Fifty-six patients, matched for age, sex, body mass index, primary diagnosis, disease etiology, NYHA score and echocardiography parameters before surgery, were selected from each group using the method of propensity score matching (PSM).

The criterion for inclusion into research: only an isolated pathology of the aortic valve;

Exclusion criteria:

• Multi-valve damage;

• Acquired heart defects requiring correction in conjunction with CABG.

• Age of patients <18 years.

1.2 Research Methods

All the patients under examination underwent a survey that included a complex of clinical, laboratory-instrumental and functional methods.

During the clinical examination of patients, the presence of indications and contraindications to this or that method of surgical correction of the cardiac pathology was being detected.

To assess the presence of obesity and its degree, a calculation of the Quetelet index was carried out.

Preoperative investigations

• 12-lead electrocardiogram;

• 24-hour ECG monitoring;

• Bicycle stress test, treadmill test, 6-minute walk test (to determine the functional class of heart failure);

• Transthoracic cardiac echocardiography (to exclude structural heart disease and determine inotropic indicators);

• Doppler echocardiography;

• Radiography;

• Complete blood test, creatinine, C-reactive protein, potassium, sodium;

• Other studies performed on individual indications (usually coronary angiography, thyroid hormones, a magnetic resonance imaging of the brain, fibrogastroscopy, an ultrasound examination of the abdominal cavity organs).

Postoperative Investigations

The clinical examinations of patients, laboratory studies, instrumental studies (electrocardiograms, echocardiographies) were performed in 5–10 days after surgery and at discharge.

Echocardiographic examinations performed in 5–10 days after surgery and in the outpatient department after 6 months, 1, 2, 3, 4 and 5 years.

Postoperative follow-up visits were performed in outpatient departments after 6 months, 1, 2, 3, 4 and 5 years.

A patient survey was conducted to analyze treatment results.

To evaluate the intensity of postoperative pain, a visual analogue scale was used. In addition, the survey was conducted to determine the ability of patients to perform simple manipulations, such as coughing, inhaling and exhaling deeply, eating, walking for a short distance and brushing their teeth.

Another survey was devoted to patients' attitudes regarding the appearance of their post-operative wounds (the cosmetic effect).

Postoperative observations, including clinical examinations, ECHO, ECG and laboratory tests were performed in 5–10 days after surgery, at discharge, on the 30th day after surgery as well as 1, 2, 3 and 4 years after surgery.

2. CLINICAL CHARACTERISTICS OF PATIENTS

2.1.1. The First Stage of the Study

The main group (N = 70) had a prevalence of men – 60.0%. The mean age was 60.8 ± 11.4 years, the Quetelet index was 27.7 ± 4.4 kg/m^2, and the majority of the patients – 34 (48.6%) – were overweight.

The control group (N = 70) also had a prevalence of men – 42 (60.0%). The mean age was 61.4 ± 11.9 years, while the Quetelet index was 27.9 ± 4.5 kg/m^2.

The clinical characteristics of the patients were similar in comparison (Table 1).

In both groups, patients with the Euroscore II 1–3% had predominated, but the median access group contained a significantly greater number of patients with the Euroscore II >3% (p = 0.049).

An analysis of comorbidities showed that chronic obstructive pulmonary disease was significantly more frequent in patients with minimally invasive access – 4 (5.7%) (p = 0.042), but all of them did not take medicines. Among patients after median sternotomy, this pathology was not diagnosed. Also, those patients who had undergone ministernomy had significantly more often suffered from hypertension (22 versus 10, p = 0.016).

There were no previous strokes before surgery in patients in the ministernotomy group, while in the sternotomy group, 2 patients had a stroke more than 90 days prior to surgery (2.86%, p = 0.154).

A coronary pathology was more common in the ministernotomy group, but the differences were not statistically significant – 4.29% versus 1.43% (p = 0.310).

Table 1 – The preoperative clinical characteristics of patients.

Indicator	**Median sternotomy (N = 70)**	**Ministernotomy (N = 70)**	**p**
Diagnosis, n (%)			
Aortic stenosis	45 (64.3%)	51 (72.9%)	0.275
Aortic regurgitation	13 (18.6%)	12 (17.1%)	0.825
Combined	12 (17.1%)	7 (10%)	0.217
Etiology of the disease, n (%)			
Senile degeneration	53 (75.71%)	53 (75.71%)	1.000
Annular expansion	12 (17.14%)	13 (18.6%)	0.825
Mitral valve	0 (0%)	1 (1.4%)	0.316
Infective endocarditis	5 (7.14%)	3 (4.3%)	0.466
EuroSCORE II			
<1%, n (%)	20 (28.6%)	24 (34.3%)	0.466
1-3%, n (%)	42 (60%)	44 (62.9%)	0.728
>3%, n (%)	8 (11.4%)	2 (2.9%)	0.049*
Euroscore_II, mean score %	1.67 ± 0.07	1.48 ± 0.45	0.256
NYHA, n (%)			
II	6 (8.6%)	12 (17.14%)	0.130
III	64 (91.4%)	57 (81.43%)	0.084
IV	0 (0%)	1 (1.43%)	0.316
International normalized ratio (INR), mean±SD	1.04 ± 0.15	1.07 ± 0.04	0.200
Creatinine clearance, (ml/min)			
<50, n (%)	36 (51.4%)	41 (58.6%)	0.396
50–85, n (%)	31 (44.3%)	27 (38.6%)	0.493
>85, n (%)	3 (4.3%)	2 (2.86%)	0.649
Mean creatinine level, μmol/l	80.93 ± 20.60	82.14 ± 15.84	0.425
The highest creatinine level, μmol/l, mean±SD	100.26 ± 60.92	92.65 ± 25.07	0.325
Hemoglobin level, g/l	129.43 ± 17.67	134.63 ± 15.85	0.165
The lowest level of hemoglobin, g/l	103.79 ± 10.77	108.71 ± 13.37	0.045*
The lowest platelet level, thousand /μl	198.68 ± 70.83	197.41 ± 70.83	0.784
Total bilirubin, μmol/l	12.19 ± 0.70	10.43 ± 0.34	0.229
Diabetes mellitus, n (%)	5 (7.1%)	11 (15.7%)	0.111
Treated with tablets	2 (2.86%)	7 (10%)	0.085
Treated with insulin	3 (4.29%)	4 (5.7%)	0.698
COPD, n (%)	0 (0%)	4 (5.7%)	0.042*

Hypertension, n (%)	10 (16.0%)	22 (31.4%)	0.016*
Peripheral vascular disease, n (%)	1 (1.4%)	0 (0%)	0.316
History of stroke, n (%)	2 (2.9%)	0 (0%)	0.154
<90 days	0 (0%)	0 (0%)	---
>90 days	2 (2.86%)	0 (0%)	0.154
Coronary artery disease, n (%)	1 (1.4%)	3 (4.3%)	0.310
Renal failure, n (%)	1 (1.4%)	2 (2.9%)	.559
Treated with diuretic	1 (1.4%)	2 (2.9%)	0.559
The use of hemofiltration	0 (0%)	0 (0%)	---
The use of hemodialysis	0 (0%)	0 (0%)	---
Anticoagulation therapy 1 week before surgery			
– Aspirin, n (%)	0 (0%)	1 (1.43%)	0.316
– Warfarin, n (%)	0 (0%)	1 (1.43%)	0.316
Rhythm disorders before surgery, n (%)			
Permanent atrial fibrillation	2 (2.9%)	6 (8.6%)	0.145
Paroxysmal atrial fibrillation	0 (0%)	2 (2.9%)	0.154
Pacemakers	2 (2.9%)	5 (7.1%)	0.245
LVEF %, n (%)			
<30%	0 (0%)	0 (0%)	----
30-49%	11 (15.7%)	16 (22.9%)	0.284
≥50%	59 (84.3%)	54 (77.1%)	0.284
Mitral valve insufficiency, in total, n (%)	30 (51.1%)	23 (32.9%)	0.223
I degree	25 (83.3%)	22 (95.7%)	0.161
II degree	5 (16.7%)	1 (4.3%)	0.161
Tricuspid valve insufficiency, in total, n (%)	22 (31.4%)	4 (5.7%)	<0.001*
I degree	22 (100%)	4 (100%)	1.00
II degree	0 (0%)	0 (0%)	---
III degree	0 (0%)	0 (0%)	---
Aortic valve insufficiency, in total, n (%)	49 (70%)	50 (71.4%)	0.246
I degree	13 (26.5%)	10 (20%)	0.591
II degree	20 (40.8%)	20 (40%)	1.000
III degree	16 (32.65%)	20 (40%)	0.620
ISTD, cm	1.16 ± 0.20	1.18 ± 0.21	0.212
LVDD, cm	5.41 ± 0.70	5.58 ± 0.75	0.398
LVSD, cm	3.66 ± 0.90	3.94 ± 0.69	0.452
PG max, mm Hg	60.62 ± 35.50	64.90 ± 40.80	0.650
PG mean, mm Hg	43.65 ± 22.50	51.79 ± 23.05	0.682

*p<0, 05 – differences between groups are significant.

2.1.2. At the Second Stage of the Study

The main group (N = 56) had a prevalence of men – 38 (67.9%). The mean age was 61.9 ± 14.1 years, the Quetelet index was 30.34 ± 4.15 kg/m^2, and the majority of the patients – 44 (78.6%) – were overweight.

The control group (N = 56) also had a prevalence of men – 36 (64.3%). The mean age was 62.08 ± 10.55 years, while the Quetelet index was 27.9 ± 4.5 kg/m^2.

A detailed assessment of the clinical characteristics showed that the most common pathology requiring surgery was the stenosis of the aortic valve, occurring in about 78.6% of the patients. Primarily, the etiology of the disease, which had led to the surgical intervention, was a senile degeneration of the aortic valve, which was observed in almost 83.9% of all patients.

In both groups, patients with the Euroscore II 1–3% had predominated. According to the NYHA classification, most patients in both groups had NYHA III – almost 85.7% of all patients.

Diabetes mellitus occurred in 11 (19.7%) patients from both groups. In the ministernotomy group, 7 patients took tablets and 4 were treated with insulin. In the median sternotomy group, 8 patients took tablets and 3 were treated with insulin.

Chronic obstructive pulmonary disease was registered in 4 (7. 1%) patients of both groups. All patients did not take medicines and did not use bronchodilators.

A coronary pathology was more common in the sternotomy group, but the differences were not statistically significant – 10.7% versus 5.4% (p = 0.410).

The preoperative characteristics of patients are presented in Table 2.

Table 2. The preoperative clinical characteristics of patients.

Indicator	**Median sternotomy (N = 56)**	**Ministernotomy (N = 56)**	**P**
Diagnosis, n (%)			
Aortic stenosis	41 (73.2%)	44 (78.6%)	0.508
Aortic regurgitation	9 (16.1%)	9 (16.1%)	1.000
Combined	6 (10.7%)	3 (5.4%)	0.297
Etiology of the disease, n (%)			
Senile degeneration	47 (83.9%)	44 (78.6%)	0.468
Annular expansion	9 (16.1%)	11 (19.6%)	0.622
Mitral valve	0 (0%)	1 (1.8%)	0.315
EuroSCORE II			
<1%, n (%)	18 (32.1%)	11 (19.6%)	0.675
1-3%, n (%)	37 (66.1%)	43 (76.8%)	0.331
>3%, n (%)	1 (1.9%)	2 (3.6%)	0.309
Euroscore II, mean score %	1.35 ± 0.70	1.40 ± 0.69	0.700
NYHA, n (%)			
II	7 (12.5%)	7 (12.5%)	1.000
III	47 (83.9%)	48 (85.7%)	0.792
IV	2 (3.6%)	1 (1.8%)	0.558

Creatinine clearance, (ml/min) *<50, n (%)* *50–85, n (%)* *>85, n (%)* Mean creatinine level, μmol/l	 2(3.6%) 22(39.3%) 32(57.1%) 83.93 ± 19.73	 34(60.7%) 21(37.5%) 1(1.8%) 82.96 ± 15.81	 0.701 0.846 0.558 0.776
International normalized ratio (INR), (mean±SD)	1.07 ± 0.09	1.36 ± 0.81	0.110
Diabetes mellitus, n (%)	11 (19.7%)	11 (19.7%)	1.000
COPD, n (%)	4 (7.1%)	4 (7.1%)	1.000
Hypertension, n (%)	12 (21.03%)	12 (20.1%)	0.203
Coronary artery disease, n (%)	6 (10.7%)	3 (5.4%)	0.410
Peripheral vascular disease, n (%)	0 (0%)	0 (0%)	---
Stroke, n (%)	0 (0%)	0 (0%)	---
Rhythm disorders, n (%) *Permanent atrial fibrillation* *Paroxysmal atrial fibrillation* *Pacemakers*	 10 (17.9%) 2 (3.6%) 2 (3.6%)	 5 (8.9%) 1 (1.8%) 3 (5.4%)	 0.557 0.559 0.647
Anticoagulation therapy 1 week before surgery	4 (7.1%)	2 (2.9%)	0.261
LVEF %, n (%) <30 % 30%-50 % ≥50%	 0 (0%) 42 (75%) 14 (25%)	 0 (0%) 16 (28.6%) 40 (71.4%)	 --- 0.580 0.654
ISTD, cm	1.21 ± 0.23	1.18 ± 0.21	0.482
LVDD, cm	5.55 ± 0.88	5.58 ± 0.75	0.822
LVSD, cm	3.77 ± 0.85	3.94 ± 0.69	0.277
PG max, mm Hg	64.22 ± 30.93	64.90 ± 40.80	0.921
PG mean, mm Hg	50.33 ± 14.06	51.79 ± 23.05	0.744
Aortic valve insufficiency, in total, n (%) *I* *II* *III*	40 (71.4%) 11 (27.5%) 17 (42.5.7%) 12 (30%)	42 (75%) 8 (19.04%) 18 (42.85%) 16 (38.09%)	0.682 0.411 0.260 0.383

*p<0, 05 – differences between groups are significant.

2.2. Operational techniques

2.2.1. PERFORMING OPERATIONS WITH MINIMALLY INVASIVE ACCESSES

The technique of operation does not differ from the technique with standard sternotomy for intraoperative indices. Tracheal intubation was performed in the usual manner by means of a single-lumen tube. For operations on the aortic valve, the ascending aorta and the right atrial appendage were cannulated and left ventricular drainage was performed through the right superior pulmonary vein.

For a cannulation of the aorta, we used both curved and straight cannulas. A two-tier venous cannula was used for venous drainage.

When performing the operations in accordance with a minimally invasive technique, myocardial protection was obtained by the patient cooling down to 26–28°C. A cardioplegic solution was fed antegradely through the aortic root or directly through the coronary openings after aortotomy. After the aortic valve replacement, the wound was stitched stepwise; a drainage of the pericardium was carried out through the drainage tubes in the epigastric region.

Under a **J-shaped ministernotomy**, a 6–7 cm skin incision was started at the level of the second rib and led to the level of the fourth rib; a sternum cut was started from the jugular fossa and led to a 4 intercostal space and then continued to the right.

Under a **W-ministernotomy**, a skin incision was started 2 cm lower than during the median sternotomy, when the standard skin incision is made along the midline to the second intercostal space. Further in the second intercostal space, the body of the sternum was intersected, starting from the two lateral sides (right and left) to the median line. Then, the body of the sternum was cut from the jugular notch to the apex of the V-type cut at the level of the second rib.

A **partial sternotomy** is not difficult access, since it can be used for repeated operations. In the case of conversion, a partial sternotomy may be extended to a median sternotomy.

During the operation, an incision was started on the jugular notch of the sternum and ended just below presternum synchondrosis (to the level of the VI intercostal space). The skin, fascia and periosteum were incised at the midline along the sternum. After stopping the ventilation of the lungs, the cut was made from top to bottom – to the presternum synchondrosis or slightly below, and then the ventilation of the lungs was resumed. Bleeding from periosteum edges was stopped using electrocoagulation and by using a spongy substance – by rubbing wax with paraffin. When using this method, it is important to perform an accurate widening of the sternum edges, because in the case of a technological violation, a transverse fracture of the sternum near the bottom end of the cutting is inevitable. For these purposes, we used a small Tuffier rib spreader.

Figures 1–3 present the implementation of the minimally invasive operations.

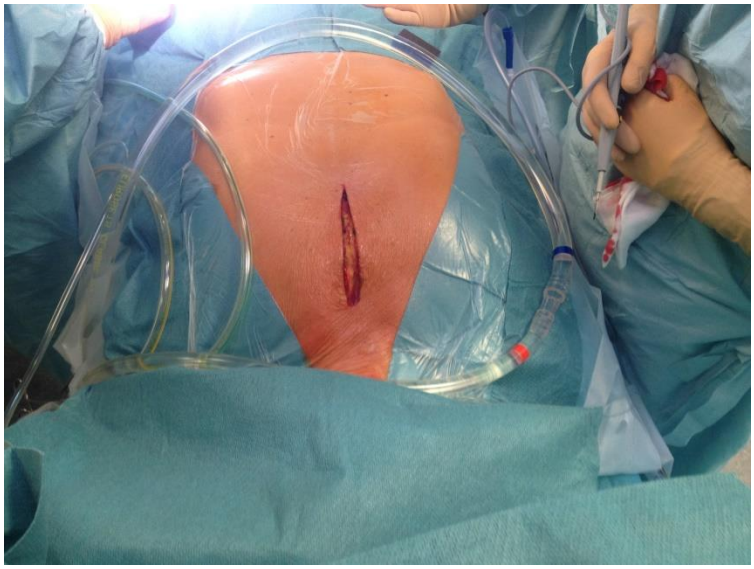

Figure 1. The size of the surgical wound under ministernotomy.

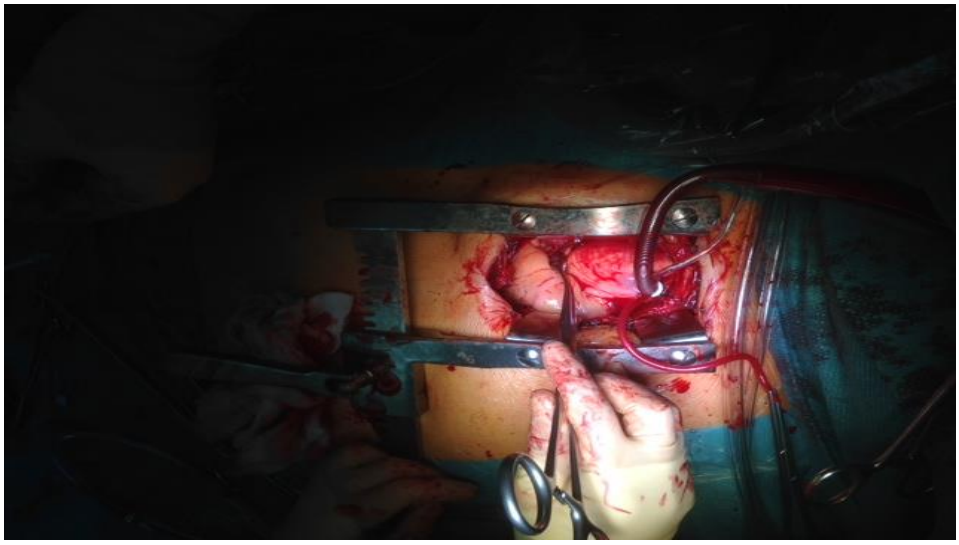

Figure 2. An operation with artificial circulation.

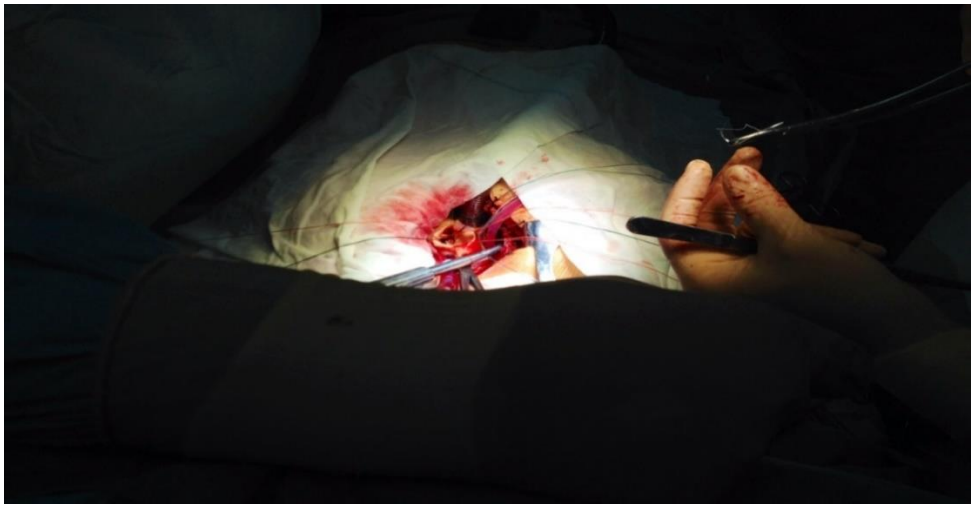

Figure 3. The course of surgery.

2.3. STATISTICAL PROCESSING

The statistical processing of the data was carried out using the methods of variation statistics and with the application package IBM SPSS 20.0 (IBM Corp., NY, US), Statistica 12" (Stat Soft., Tulsa, OK, US) and the R packages party and rpart.

Data evaluation for normal distribution was carried out using a Lilliefors normality test, whereby it was found that the data are not normally distributed. Accordingly, nonparametric statistical methods were used for processing the results. A Kruskal-Wallis test was used to test median difference, and the exact significance level of differences between the groups was calculated using the Mann-Whitney method.

To analyze the differences in the frequencies between two independent groups of research subjects and test the null statistical hypothesis, we used a chi-square Mantel-Haenszel and a Fisher's exact tests (for small numbers with a binomial distribution, if the number of observations in one or more cells of 2x2 tables was ≤5).

In processing the survey data, a survival analysis using a Kaplan-Meier and Long-rank test was conducted. In the tables, data are presented as mean values and mean value errors (M ± m).

The results obtained were evaluated with the help of the p-value. This is the probability of the random nature of the effect obtained in the study. The P-value assesses the overall statistical significance of differences between groups. The value of $p \leq 0.05$ was made to be a condition of statistical significance.

CHAPTER 3. RESULTS OF OWN RESEARCH

3.1. AN ASSESSMENT OF INDICATORS IN SELECTED GROUPS OF PATIENTS

3.1.1 OPERATIVE INDICATORS

An estimation of surgery duration in selected groups of patients showed that the duration of the operation in the two groups was comparable regardless of access type ($p = 0.856$).

In the ministernotomy group, a biological valve was installed significantly more often, and in the median sternotomy group, a mechanical valve was installed significantly more often, $p<0.001$. The frequency of the use of valves having different sizes was comparable in the two groups.

The most popular manufacturer of valves in both groups was St. Jude – in 88.57% of the patients; this firm prevailed in patients with median access in 74.29% of all cases. Under median sternotomy, valves manufactured by a company belonging to the Sorin group were used significantly more frequently – 8.57% versus 0.0% in the ministernotomy group ($p = 0.012$).

Ministernotomies required longer Aortic cross-clamping times during the surgeries. On average, in the main group of the patients, the aorta was clamped 8 minutes longer than in the control group of patients (p = 0.007).

The use of extracorporeal circulation was longer under ministernotomy. It lasted almost 12 minutes longer than under sternotomy (p = 0.049).

During resternotomy, an extracorporeal membrane oxygenation (ECMO) was used in 1 patient (1.4%) undergoing ministernotomy. This procedure was not used among the selected patients of the median access group (p = 0.428). An intra-aortic balloon pump was not used in any patient of the selected groups.

The operation characteristics of the two groups of patients are presented in Table 3.

Table 3. The characteristics of the operative performance in groups.

Indicator	**Median sternotomy (N = 70)**	**Ministernotomy (N = 70)**	**p**
Surgery duration (min), (mean±SD)	256.9 ± 79.7	263.5 ± 62.0	0.856
Aortic cross-clamping time (min), (mean±SD)	80.3 ± 24.6	88.7 ± 20.7	0.007*
Cardiopulmonary bypass time (min), (mean±SD)	132.9 ± 44.9	144.0 ± 29.9	0.049*
Number of cardioplegia cycles	4.42 ± 1.40	4.30 ± 1.01	0.779
Cardioplegia duration, (min)	18.23 ± 9.80	17.14 ± 7.94	0.259
The first cardioplegia, n (%) *Aortic root* *Coronary mouth* *Retrograde cardioplegia*	 1 (1.4%) 60 (85.7%) 9 (12.9%)	 12 (17.1%) 58 (82.9%) 0 (0%)	 0.001* 0.642 0.002*
Cardioplegia during surgery, n (%) *Retrograde cardioplegia* *Coronary mouth* *Combined*	 4 (5.7%) 30 (42.9%) 36 (51.4%)	 0 (0%) 70 (100%) 0 (0%)	 0.042* <0.001* <0.001*
Cardioplegic solution, n (%) *Pharmaco-cold cardioplegia* *Cold blood cardioplegia*	 37 (52.9%) 33 (47.1%)	 62 (88.6%) 8 (11.4%)	 <0.001* <0.001*
Repeated cardioplegia, n (%)	3 (4.3%)	0 (0.0%)	0.080
Aortotomy type, n (%) *Transverse aortotomy* *Hockey stick aortotomy*	 6 (8.6%) 64 (91.4%)	 32 (45.7%) 38 (54.3%)	 <0.001* <0.001*
Bleeding during surgery, n (%) *Source – aortotomy* *Other source*	1 (1.4%) 1 (1.4%) 0 (0%)	0 (0%) 0 (0%) 0 (0%)	0.316 0.316 ---
The lowest patient's body temperature during surgery,°C	28.45 ± 2.40	28.05 ± 0.87	0.668

Valve type, n (%) *Biological* *Mechanical*	 24 (34.3%) 46 (65.7%)	 60 (85.7%) 10 (14.3%)	 <0.001* <0.001*
Aortic valve size, n (%) *19 mm* *21 mm* *23 mm* *25 mm* *27 mm* *29 mm*	 0 (0%) 7 (10%) 36 (51.4%) 19 (27.14%) 8 (11.43%) 0 (0%)	 0 (0%) 4 (5.7%) 33 (47.1%) 29 (41.4%) 4 (5.7%) 0 (0%)	 --- 0.346 0.612 0.075 0.227 ---
Aortic valve manufacturer, n (%) *St. Jude* *ATS* *Sorin* *Medronic Hall*	 52 (74.3%) 0 (0.0%) 6 (8.6%) 12 (17.1%)	 62 (88.6%) 2 (2.86%) 0 (0%) 6 (8.57%)	 0.030* 0.154 0.012* 0.130
Additional procedures, n (%) *Aortic root widening* *Left atrial appendage ligation*	 1 (1.4%) 0 (0%)	 0 (0%) 6 (8.6%)	 0.316 0.012*
ECMO, n (%)	0 (0%)	1 (1.4%)	0.428
IABP, n (%)	0 (0%)	0 (0%)	---

*p<0.05 – differences between the groups are significant.

3.1.2. AN EVALUATION OF POSTOPERATIVE INDICATORS

The duration of artificial lung ventilation under a ministernotomy was 2 hours shorter (p<0.001).

The number of patients with more than 1000 ml of blood loss within 24 hours after surgery was not significantly different in both groups. The amount of blood flowing through the drain during 24 hours after surgery in the ministernotomy group was almost 150 ml smaller (p<0.001).

The number of patients who underwent a transfusion of platelets, fresh frozen plasma (FFP) or red blood cells in the two groups did not differ significantly.

Postoperative bleeding occurred in 1 patient from the ministernotomy group (1.4%) and in 2 patients (2.9%) from the sternotomy group (p = 0.559). In all cases, an aortotomy did not cause any bleeding.

Drug-induced coagulopathy correction was required in 14 patients of the control group (20.0%). Protamine was used for this purpose in all patients. In the ministernotomy group, no patients required a drug correction of coagulopathy (p<0.001).

The duration of hospitalization in the ministernotomy group of patients was significantly shorter – almost by 3 days (p = 0.012). However, if we take into account the length of the hospital stay after the operation, the differences between the groups become no longer statistically significant (p = 0.113). The length of the patients' stays in the ICU also did not differ significantly.

The mortality rate in both groups was comparable – no deaths were recorded during surgery. Postoperative mortality under ministernotomy was equal to 1.4% – 1 patient died. This occurred on the 7th day. In patients after a median sternotomy, no fatal outcomes were recorded in the postoperative.

There were no cases of reintervention in any of the groups.

Postoperative wound infection occurred in two patients of the ministernotomy group – in 1 (1.4%) patient, it was treated with antibiotics alone, and in the other, vacuum-assisted closure therapy was used. In the median access group, this complication occurred in two patients – one was treated with antibiotics, and the other underwent sternum drainage with washing.

A cardiac tamponade was reported in 1 patient from the median sternotomy group and in 1 patient from the minimal access group (p = 1.000). In all cases, the treatment of complications was carried out in the ICU.

Acute renal failure occurred in 2.9% (2 patients) of patients in the ministernotomy group and in 1.4% (1 patient) of patients in the median sternotomy group. All patients were treated with medicines.

The incidence of different variants of arrhythmias in the postoperative period in the two groups did not differ significantly. In the postoperative period, a pacemaker implantation was required in 3 patients from the ministernotomy group and 4 patients from the median access group (p = 0.698).

The features of the postoperative outcomes of patients in both groups are presented in Table 4.

Table 4. The characteristics of the postoperative outcomes in groups.

Indicator	**Median sternotomy (N = 70)**	**Ministernotomy (N = 70)**	**p**
Ventilation time (h), (mean±SD)	11.7 ± 1.4	9.7 ± 1.7	<0.001*
Blood loss≥1000 mL/24 h, n (%)	2 (2.9%)	1 (1.4%)	0.559
24h chest tube drainage (mL), (mean±SD)	407.25 ± 40.37	256.2 ± 28.6	<0.001*
Number of patients, who underwent red blood cells transfusion, n (%)	15 (21.4%)	12 (17.1%)	0.520
Red blood cells transfused, in total, ml	572.2 ± 82.1	505.4 ± 79.4	0.215
Number of patients, who underwent platelets transfusion, n (%)	1 (1.4%)	4 (5.7%)	0.172
Platelets transfused, in total, ml	95.0 ± 25.02	435.0 ± 177.4	0.881
Number of patients, who underwent FFP transfusion, n (%)	5 (7.1%)	1 (1.4%)	0.095
Fresh frozen plasma transfused, in total, ml	935.80 ± 146.17	1040 ± 423.35	0.898

Drug correction of coagulopathy, n (%)	14 (20%)	0 (0%)	<0.001*
ICU stay (h), (mean±SD)	88.14 ± 20.62	68.97 ± 6.29	0.319
Hospital stay (days), (mean±SD)	21.9 ± 1.9	18.3 ± 1.9	0.012*
Hospital stay, post-surgery (days), (mean±SD)	15.2 ± 1.5	13.0 ± 1.0	0.113
Intraoperative mortality, n (%)	0 (0%)	0 (0%)	---
30-day mortality, n (%)	0 (0%)	1 (1.4%)	0.316
Resternotomy, n (%)	2 (2.9%)	1 (1.4%)	0.559
Bleeding, n (%) Source – aortotomy Other source	2 (2.9%) 0 (0%) 2 (2.9%)	1 (1.4%) 0 (0%) 1 (1.4%)	0.559 --- 0.559
Endocarditis, n (%) *Treated with drugs* *Treated with surgery*	5 (7.1%) 5 (7.1%) 0 (0.0%)	1 (1.4%) 1 (1.4%) 0 (0.0%)	0.095 0.095 ---
Valve thrombosis, n (%)	0 (0%)	0 (0%)	---
wound infection, n (%) *Superficial wound infection - treated with antibiotic only* *Mediastinitis - treated with VAC* *Mediastinitis - treated with sternum drainage* *Mediastinitis - treated with sternum drainage with washing*	2 (2.9%) 1.43% 0(0%) 0(0%) 1.43%	2 (2.9%) 1 (1.4%) 1 (1.4%) 0(0%) 0(0%)	1.000 1.000 0.316 --- 0.316
Cardiac tamponade, n (%)	1 (1.4%)	1 (1.4%)	1.000
Acute renal failure, n (%) *Treated with a diuretic* *Treated with a hemofiltration* *Treated with a hemodialysis*	1 (1.4%) 1 (1.4%) 0 (0%) 0 (0%)	2 (2.9%) 2 (2.9%) 0 (0%) 0 (0%)	0.559 0.559 --- ---
Embolism, n (%), *In the form of a neurological disorder* *In the form of a stroke*	 1 (1.4%) 0 (0%)	 2 (2.9%) 0 (0%)	 0.559 ---
Cardiac rhythm at discharge, n (%) *Sinus rhythm* *Atrial fibrillation* *An implantation of a pacemaker within the period from surgery to discharge*	 63 (90%) 3 (4.3%) 4(5.71%)	 59 (84.3%) 4(5.7%) 3(4.29%)	 0.098 0.698 0.698
An implantation of a pacemaker within the whole postoperative period, n (%)	4(5.71%)	3(4.29%)	0.698
LVEF%, n (%), at discharge *<30%* *30-49%* *≥50%*	(n = 70) 0 (0%) 13 (18.6%) 57 (81.4%)	(n= 69) 0 (0%) 12 (17.4%) 57 (82.6%)	 --- 0.856 0.856
PG max, (mm Hg), at discharge	28.31 ± 7.30	33.57 ± 3.64	0.006*
PG mean, (mm Hg), at discharge	17.08 ± 6.92	23.41 ± 2.65	0.015*
ISTD, cm	1.20 ± 0.23	1.28 ± 0.21	0.788
LVDD, cm	5.10 ± 0.60	5.11 ± 0.16	0.910
LVSD, cm	3.65 ± 0.85	3.26 ± 0.25	0.065

*p<0.05 – differences between the groups are significant.

An evaluation of drug therapy for the hemodynamic support showed that adrenalin was significantly more often used in the median access group – 30.0% against 5.71% in the ministernotomy group (p<0.001). No significant differences neither in the duration of medicine taking nor in its maximum dose were found between the groups.

An evaluation of the use of drugs for pain relief has shown that morphine was significantly more often used under median access – 98.57% against 90.00% in the ministernotomy group (p = 0.029), and in the ministernotomy group, non-steroidal, anti-inflammatory drugs were also significantly more often used – 98.57% versus 78.57% (p<0.001) (Table 5).

Table 5. The characteristics of medications used in groups.

Indicator	**Median sternotomy (N = 70)**	**Ministernotomy (N = 70)**	**p**
Preparations for maintaining the hemodynamic			
The number of patients treated with adrenaline, n (%)	21 (30%)	4 (5.71%)	<0.001*
The duration of treatment with adrenaline (hours)	27.23 ± 3.03	4.75 ± 2.75	0.314
The maximum dose of adrenaline, μg/kg/min	0.05 ± 0.001	0.05 ± 0.001	0.910
The number of patients treated with noradrenaline, n (%)	43 (61.43%)	42 (60.0%)	0.863
The duration of treatment with noradrenaline (hours)	37.21 ± 4.93	23.06 ± 4.06	0.236
The maximum dose of noradrenaline, μg/kg/min	0.05 ± 0.01	0.05 ± 0.01	0.913
The number of patients treated with dopamine, n (%)	5 (7.14%)	6 (8.57%)	0.753
The duration of treatment with dopamine (hours)	31.70 ± 3.40	18.33 ± 1.95	0.625
The maximum dose of dopamine, μg/kg/min	10.08 ± 2.41	6 ± 2.02	0.750
The number of patients treated with dobutamine, n (%)	6 (8.57%)	6 (8.57%)	1.00
The duration of treatment with dobutamine (hours)	34 ± 9.18	8.33 ± 1.17	0.415
The maximum dose of dobutamine, μg/kg/min	4 ± 1	4.68 ± 0.54	0.894
The number of patients treated with nitroglycerine, n (%)	4 (5.71%)	4 (5.71%)	1.00
The duration of treatment with nitroglycerine (min)	24 ± 4	9 ± 3.11	0.103
The maximum dose of nitroglycerine, μg/ min	0.44 ± 0.007	0.45 ± 0.001	0.916

Preparations for anesthesia			
Morphine, n (%)	69 (98.57%)	63 (90%)	0.029*
Tramadol, n (%)	0 (0%)	3 (4.62%)	0.080
Nonsteroidal anti-inflammatory drugs (other than paracetamol), n (%)	69 (98.57%)	55 (78.57%)	<0.001*
Paracetamol, n (%)	48 (68.57%)	54 (77.14%)	0.254

*p<0.05 – differences between the groups are significant.

A survey of the patients showed an increase in patient satisfaction with the treatment performed after a ministernotomy due to the faster return to daily activities and a better cosmetic effect.

In 7 days after the operations took place, we asked patients whether they were able to perform simple actions (Figure 4).

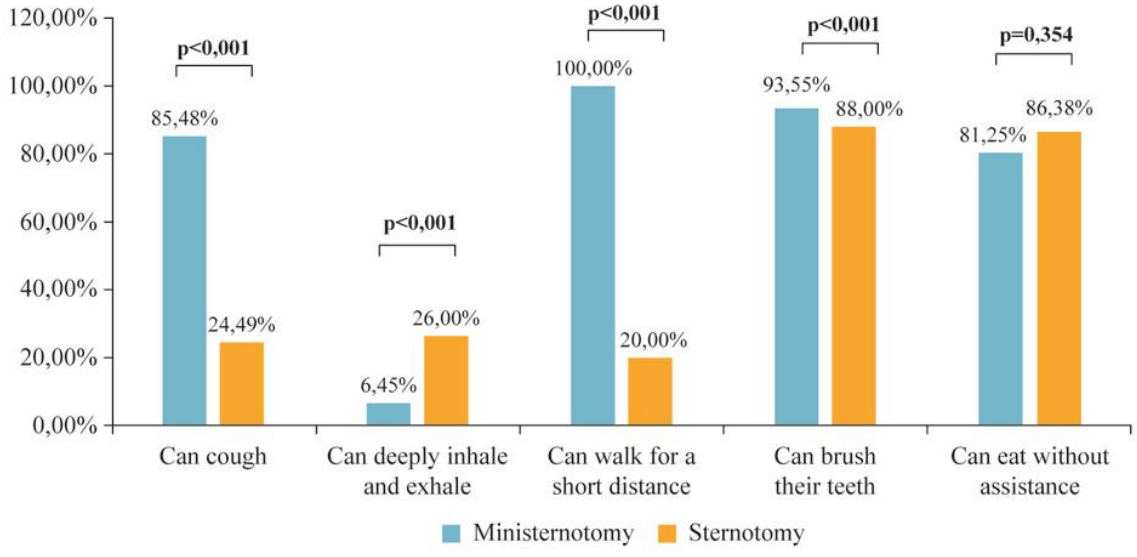

Fig. 4. The ability to perform simple actions in both groups of patients.

Just as in large samples of patients, we noted that among the patients from the ministernotomy group, the ability to perform simple actions during the first week after surgery was identified in a significantly greater number of patients (p<0.0001). There were no significant differences between the groups in regard to meal intake.

The results of the patients' surveys regarding the cosmetic effects of both methods are shown in Figure 5.

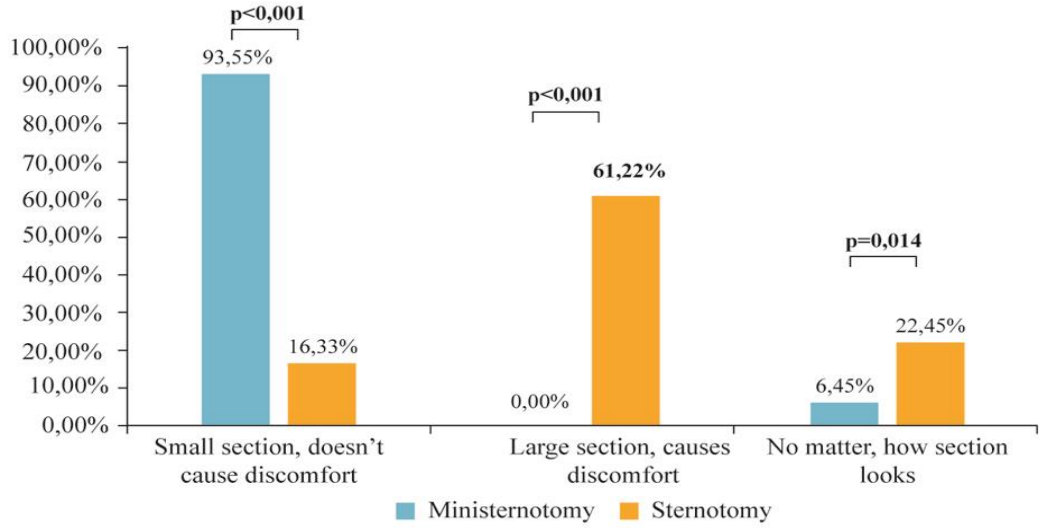

Fig 5. The opinion of patients on the postoperative section.

In the ministernotomy group, there were no patients insufficient with the surgical wound size. At the same time, in the sternotomy group, most patients responded that the section is large and causes discomfort.

To clarify the intensity of the pain syndrome, a patient survey was conducted using the Visual Analog Pain Scale. The results are shown in Figure 6.

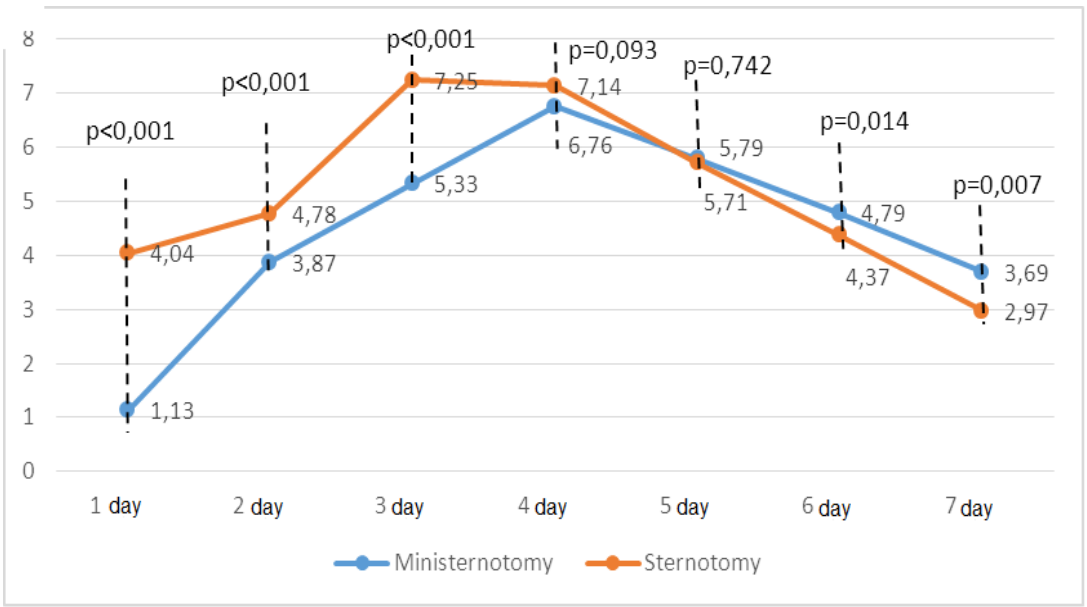

Figure 6. The dynamics of the patients' pain assessment according to VAS.

We noted similar dynamics of pain syndrome in patients of both groups with a gradual increase in pain by the 4–5th day. At the same time, in patients from the ministernotomy group, the pain sensations from the 1st to the 3rd day were significantly smaller. On the 4–5th day, the pain syndrome intensity in patients from both groups became approximately equal and later decreased, while it was less pronounced in the sternotomy group. As a result of this, on the 6–7th day, its level in this group became reliably lower than in the main group.

To monitor the distant results of surgery, echocardiography indicators, the NYHA stage and clinical symptoms were examined for several years.

On the 30th day, patients were compared by the NYHA severity degree. Thoracalgia was met among the clinical symptoms in both groups with a comparable frequency (Table 6).

Table 6. The 30-day patient results.

Indicator	**Median sternotomy (N = 70)**	**Ministernotomy (N = 69)**	**P**
NYHA, n (%)			
I	0 (0%)	0 (0%)	---
II	48 (68.6%)	46 (66.7%)	0.810
III	22 (31.4%)	23 (33.3%)	0.810
Clinical complaints, n (%)	(n = 70)	(n = 65)	
Absent	62 (88.6%)	59 (90.7%)	0.676
Thoracalgia	8 (11.4%)	6 (9.2%)	0.676
Pain behind the breastbone	0 (0%)	0 (0%)	---
Dyspnea	0 (0%)	0 (0%)	---
Sleep disturbances	0 (0%)	0 (0%)	---
LVEF %, n (%)			
<30%	0 (0%)	0 (0%)	---
30-50%	4 (5.7%)	8 (11.6%)	0.217
>50%	66 (94.3%)	61 (88.4%)	0.217

*p<0.05 – differences between the groups are significant.

Results of the 90th day showed that in the sternotomy group, the number of patients with NYHA I was significantly higher (p = 0.033).

Among the clinical symptoms in both groups, the most common was thoracology. It was met among the clinical symptoms in both groups with a comparable frequency.

Two patients from the minimally invasive access group underwent coronary angiography, while no patients from the median access group underwent this procedure (p = 0.154) (Table 7).

Table 7. The 90-day patient results.

Indicator	Median sternotomy (N = 70)	Ministernotomy (N = 69)	P
NYHA, n (%)			
I	28 (40%)	16 (23.2%)	0.033*
II	36 (51.4%)	45 (65.2%)	0.099
III	6 (8.6%)	8 (11.6%)	0.554
Clinical complaints, n (%)	(n = 67)	(n = 64)	
Absent	52 (77.6%)	53 (82.8%)	0.635
Thoracalgia	8 (11.9%)	6 (9.4%)	0.635
Pain behind the breastbone	1 (1.5%)	1 (1.7%)	0.948
Dyspnea	0 (0%)	3 (4.7%)	0.135
Edema	1 (1.5%)	0 (0%)	0.337
Palpitation	5 (7.5%)	1 (1.7%)	0.201
Cardiac interventions, n (%)	(n = 69)	(n = 69)	
Pacemaker	4 (5.83%)	3 (4.3%)	0.227
Coronarography	0 (0%)	2 (2.90%)	0.154
Angioplasty	0(0%)	0 (0%)	---
LVEF %, n (%)	(n = 69)	(n = 69)	
<30%	0 (0%)	0 (0%)	---
30–50%	2 (2.9%)	5 (7.3%)	0.245
>50%	67 (97.1%)	64 (92.7%)	0.245

*p<0, 05 – differences between groups are significant.

A year later, no significant differences in the frequency of the occurrence of varying NYHA severity degrees were found in the groups. Under ministernotomy, the number of patients with no complaints was significantly larger. In this group, only one patient complained of experiencing chest pains, while in the median access group, 5.2% of all patients suffered from dyspnea. There were no new cardiac surgeries during the period (Table 8).

Table 8. The 360-day patient results.

Indicator	Median sternotomy (N = 58)	Ministernotomy (N = 69)	P
NYHA, n(%)			
I	32 (55.2%)	34 (49.3%)	0.508
II	24 (41.4%)	35 (50.7%)	0.293
III	2 (3.5%)	0 (0.0%)	0.120
Clinical complaints, n (%)	(n = 57)	(n = 61)	
Absent	46 (80.7%)	60 (98.4%)	0.002*
Thoracalgia	8 (14%)	1 (1.6%)	0.078
Angina pectoris	0 (0%)	0 (0%)	---
Dyspnea	3 (5.2%)	0 (0%)	0.070
Palpitation	0 (0%)	0 (0%)	---
Edema	0 (0%)	0 (0%)	---

LVEF %, n (%)	(n = 55)	(n = 54)	
<30%	0 (0%)	0 (0%)	---
30-50%	5 (9.1%)	2 (3.7%)	0.251
>50%	50 (90.9%)	52 (96.3%)	0.251

*p<0, 05 – differences between groups are significant.

In the future, there were no significant differences between the groups (Tables 9–10).

Table 9. The 2nd year patient results.

Indicator	**Median sternotomy (N = 46)**	**Ministernotomy (N = 69)**	**P**
NYHA, n (%)	(n = 39)	(n = 69)	
I	30 (76.9%)	51 (73.9%)	0.760
II	9 (23.1%)	18 (26.1%)	0.760
III	0 (0%)	0 (0%)	---
Clinical complaints, n (%)	(n = 41)	(n = 66)	
Absent	40 (97.6%)	66 (100%)	0.202
Thoracalgia	0 (0%)	0 (0%)	---
Pain behind the breastbone	0 (0%)	0 (0%)	---
Dyspnea	0 (0%)	0 (0%)	---
Edema	0 (0%)	0 (0%)	---
Palpitation	1 (2.4%)	0 (0%)	0.202
LVEF %, n (%)	(n = 46)	(n = 34)	
<30%	0 (0.0%)	0 (0.0%)	
30–50%	22 (47.8%)	2 (5.9%)	0.330
>50%	24 (52.1%)	32 (94.1%)	0.330

*p<0, 05 – differences between groups are significant.

Table 10. The 3rd year patient results.

Indicator	**Median sternotomy (N = 51)**	**Ministernotomy (N = 69)**	**P**
NYHA, n (%)	(n = 23)	(n = 69)	
I	20 (86.9%)	60 (87.0%)	1.00
II	3 (13%)	9 (13%)	1.00
III	0(0%)	0(0%)	---
Clinical complaints, n (%)	(n = 39)	(n = 20)	
Absent	39 (100%)	20 (100%)	1.00
Thoracalgia	0 (0%)	0 (0%)	---
Pain behind the breastbone	0 (0%)	0 (0%)	---
Edema	0 (0%)	0 (0%)	---
Palpitation	0 (0%)	0 (0%)	---
LVEF %, n (%)	(n = 39)	(n = 25)	
<30%	0 (0%)	0 (0%)	---
30-50%	3 (7.7%)	0 (0%)	0.155
>50%	36 (92.3%)	25 (100%)	0.155

*p<0, 05 – differences between groups are significant.

In the 4th and 5th years after the surgeries, we did not reveal any statistically significant differences between the groups – either in the clinical picture or in echocardiography results. However, it should be noted that we were able to trace the data of only 7 patients in each group, so it's possible that differences may occur with an increase in the sampling number.

Thus, we have observed that the major differences between the two operational techniques are observed in the early postoperative period. With the observation period increasing, the differences between groups are leveled.

These data were confirmed by an analysis using the Kaplan-Meier methodology. It is noted that the five-year survival of the ministernotomy group's patients was 91.4%, and in the median sternotomy group, it was 97.1%. When using the Long Rank test, no significant differences were found: p = 0.054 (Figure 7).

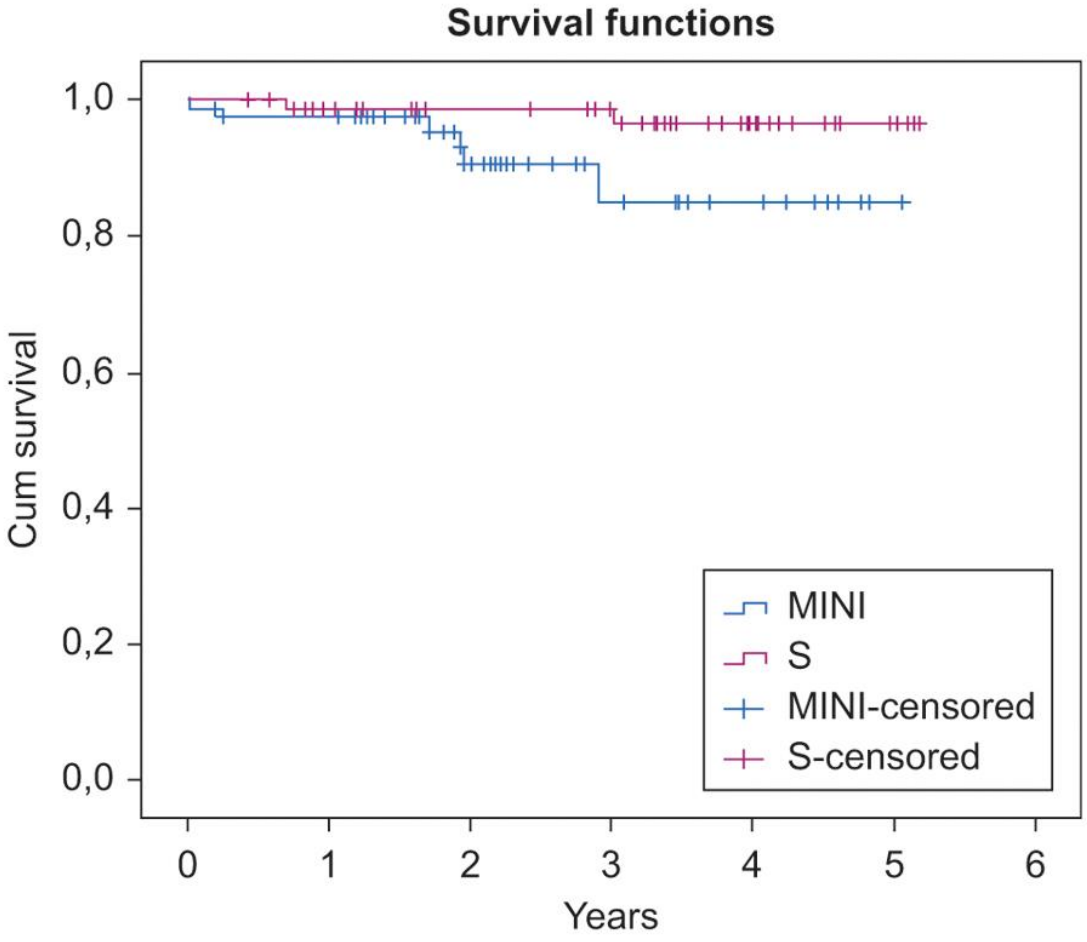

Fig 7. The Kaplan-Meier curves.

Thus, when comparing identical groups, we observed more favorable postoperative indicators under ministernotomy. In particular, there was a reduction in the duration of artificial lung ventilation, a reduction in the incidence of coagulopathy and its pharmacological treatment, a decreased length of hospital stay and the best subjective feelings of th patients. During the long-term follow-up, we have not found any significant differences between the groups in most cases; thus, ministernotomy can be recommended as priority access when performing surgery to replace the aortic valve.

3.2. PECULIARITIES OF THE INFLUENCE OF PRE-OPERATIVE INDICATORS ON THE COURSE OF SURGERY AND ON THE COURSE OF THE NEAREST POST-OPERATIVE PERIOD

Since we had identified the differences in surgical and in post-operative phases in two groups of patients, we decided to conduct a correlation analysis to identify whether the preoperative indicators' effect on the surgery course and on the early postoperative period in patients from the ministernotomy and median access groups is the same.

The following table shows the impact of preoperative indicators on the course of surgery in the ministernotomy and sternotomy groups (Tables 11–14).

Table 11. The influence of preoperative indicators on the course of surgery in the median sternotomy group.

Indicator	The loweast patient's temperature during surgery, °C	Aorta clamping duration (min)	Extracorporeal circulation duration (min)	Number of cardioplegia cycles	Cardioplegia duration (min)	Surgery duration (min)
Age	0.058	**-0.240***	-0.152	-0.071	**-0.262***	-0.067
p	0.641	**0.049***	0.216	0.565	**0.031***	0.587
BMI	0.023	-0.079	-0.118	-0.044	0.090	0.013
p	0.851	0.521	0.337	0.720	0.466	0.920
Hemoglobin level	-0.295	-0.065	-0.087	-0.052	-0.036	0.199
p	0.153	0.758	0.681	0.805	0.866	0.339
Creatinine level	0.111	0.308	0.376	0.311	0.100	0.251

p	0.597	0.135	0.064	0.130	0.635	0.226
Bilirubin level	0.088	-0.007	-0.038	0.023	-0.122	-0.292
p	0.676	0.974	0.857	0.912	0.561	0.157
Blood clotting	0.091	0.312	**0.555***	0.188	0.000	0.379
p	0.666	0.129	**0.004***	0.367	0.999	0.062
Euroscore II	-0.015	**0.445***	**0.477***	**0.578***	0.269	**0.536***
p	0.945	**0.026***	**0.016***	**0.002***	0.193	**0.006***
ISTD	0.142	0.173	0.195	0.121	0.043	0.040
p	0.499	0.407	0.349	0.564	0.840	0.850
LVDD	0.236	-0.137	-0.155	-0.129	-0.065	-0.163
p	0.255	0.512	0.460	0.539	0.756	0.436
LVSD	0.191	-0.063	-0.034	-0.138	-0.093	0.100
p	0.361	0.764	0.870	0.510	0.659	0.634
PG max	**0.398***	-0.002	-0.225	0.071	-0.222	-0.249
p	**0.049***	0.993	0.280	0.735	0.287	0.230
PG mean	0.264	-0.024	-0.218	0.083	-0.209	-0.284
p	0.202	0.910	0.296	0.692	0.317	0.169

*$p<0.05$ – differences between the groups are significant.

As can be seen from the data presented in the sternotomy group, age affects the duration of aortic clamping ($r = -0.240$, $p = 0.049$) and the duration of cardioplegia ($r = -0.262$, $p = 0.031$). The duration of cardiopulmonary bypass, to our knowledge, is directly proportional to blood clotting ($r = 0.555$, $p = 0.004$).

The largest number of indicators proved to be dependent on the Euroscore. These indicators include the duration of surgery, aortic clamping time, the duration of cardiopulmonary bypass and the number of cardioplegia cycles. In all cases, a correlation of medium strength was observed.

Also, a weak correlation between the level of the maximum gradient on the aortic valve and the lowest patient's body temperature during surgery was found ($r = 0.398$, $p = 0.049$).

Table 12. The influence of preoperative indicators on the course of surgery in the ministernotomy group.

Indicator	The loweast patient's temperature during surgery, °C	Aorta clamping duration (min)	Extracorporeal circulation duration (min)	Number of cardioplegia cycles	Cardioplegia duration (min)	Surgery duration (min)
Age	-0.007	0.044	0.180	-0.150	-0.127	0.190
p	0.958	0.721	0.139	0.218	0.297	0.131
BMI	0.043	-0.160	**-0.251**	-0.112	-0.160	0.063
p	0.725	0.191	**0.037***	0.360	0.189	0.608

Hemoglobin level	-0.034	0.179	0.255	-0.024	0.214	-0.034
p	0.813	0.205	0.068	0.867	0.127	0.813
Creatinine level	**0.287**	0.102	0.179	0.069	-0.075	**0.287**
p	**0.039***	0.470	0.204	0.625	0.596	**0.039***
Bilirubin level	-0.047	0.026	0.121	0.111	0.079	-0.047
p	0.742	0.857	0.394	0.433	0.578	0.742
Blood clotting	-0.232	0.069	0.038	0.114	-0.128	0.089
p	0.098	0.629	0.788	0.420	0.364	0.522
Euroscore II	-0.130	0.087	0.208	-0.153	-0.088	0.109
p	0.358	0.538	0.139	0.279	0.533	0.430
ISTD	-0.025	0.184	0.151	0.244	0.032	0.124
p	0.862	0.192	0.286	0.081	0.824	0.366
LVDD	0.067	-0.045	-0.006	0.107	0.234	0.123
p	0.639	0.753	0.969	0.452	0.095	0.375
LVSD	0.059	-0.251	-0.156	0.026	0.127	0.102
p	0.679	0.073	0.269	0.855	0.371	0.476
PG max	-0.065	-0.101	-0.212	0.067	0.101	0.108
p	0.651	0.481	0.135	0.641	0.482	0.434
PG mean	-0.203	-0.078	-0.113	0.111	0.227	0.119
p	0.430	0.522	0.522	0.872	0.914	0.372

*$p<0.05$ – differences between the groups are significant.

It is important to note that there are much less factors influencing operative performance in the ministernotomy group. They include the body mass index, which influences the duration of cardiopulmonary bypass ($r = -0.251$, $p = 0.037$), and the creatinine level, which correlates with the lowest body temperature of the patient at the time of the operation and the duration of surgery ($r = 0.287$, $p = 0.039$) (see Table 12).

When assessing the impact of preoperative indicators on the course of the postoperative period, we noted the influence of the patient's age at the lowest rates of Hb in the median access group ($r = -0.315$, $p = 0.013$). According to our data, the hemoglobin level before surgery influenced the duration of the patient's stay in the intensive care unit ($r = -0.408$, $p = 0.048$). The creatinine level also correlated with the duration of patient stay in the intensive care unit ($r = 0.458$, $p = 0.024$), the duration of artificial lung ventilation ($r = 0.513$, $p = 0.010$) and the duration of hospitalization ($r = 0.409$, $p = 0.047$). The Euroscore rating correlated with the duration of artificial lung ventilation ($r = 0.494$, $p = 0.014$) and the amount of blood that flowed through drainage during the first 24 hours ($r = 0.462$, $p = 0.023$) (see Table 13).

Table 13. The influence of preoperative indicators on the course of the postoperative period in the median sternotomy group.

Indciator	Stay duration in an intensive care unit	Ventila-tion time (h)	Amount of blood flown through drainage	Hospita-lization duration (in total)	Hospitali-zation duration (since the day of surgery)	The lowest hemoglobin level after surgery	The lowest platelets level
Age	-0.090	-0.144	-0.006	0.124	0.198	**-0.315**	-0.187
p	0.485	0.266	0.961	0.337	0.123	**0.013***	0.145
BMI	-0.232	-0.090	0.034	-0.074	-0.217	-0.055	-0.235
p	0.070	0.489	0.795	0.565	0.091	0.670	0.066
Hemoglobin level	**-0.408**	-0.021	0.261	0.019	0.049	0.236	0.164
p	**0.048***	0.921	0.219	0.930	0.821	0.266	0.444
Creatinine level	**0.537**	**0.443**	0.165	0.208	0.104	-0.127	0.087
p	**0.007***	**0.030***	0.441	0.329	0.630	0.555	0.687
Bilirubin level	0.090	0.165	-0.044	-0.174	-0.076	-0.256	0.190
p	0.677	0.442	0.837	0.416	0.725	0.227	0.373
Blood clotting	**0.458**	**0.513**	0.064	**0.409**	0.270	0.027	0.102
p	**0.024***	**0.010***	0.765	**0.047***	0.202	0.902	0.636
Euroscore II	0.350	**0.494**	**0.462**	0.180	-0.014	-0.176	-0.345
p	0.093	**0.014***	**0.023***	0.400	0.947	0.411	0.099
ISTD	0.193	0.179	0.242	-0.081	-0.167	-0.064	0.293
p	0.366	0.402	0.255	0.707	0.436	0.768	0.165
LVDD	-0.199	-0.058	-0.038	-0.328	-0.281	-0.084	-0.107
p	0.352	0.787	0.859	0.118	0.183	0.698	0.618
LVSD	-0.030	0.101	-0.042	-0.326	-0.322	-0.242	-0.312
p	0.891	0.638	0.847	0.121	0.126	0.255	0.138
PG max	-0.005	-0.198	-0.108	0.168	0.293	0.178	0.043
p	0.980	0.353	0.617	0.432	0.165	0.406	0.843
PG mean	0.049	-0.200	0.015	0.015	0.129	0.116	0.057
p	0.821	0.348	0.946	0.946	0.549	0.589	0.791

*$p<0.05$ – differences between the groups are significant.

In the ministernotomy group, the course of the postoperative period was influenced by the patient's age, which affected the duration of stay in the intensive care unit ($r = 0.268$, $p = 0.030$), and by the level of creatinine, which correlated with the duration of hospitalization ($r = 0.478$, $p = 0.003$). According to our data, the end-systolic dimension of the left ventricle may also affect the duration of hospitalization ($r = 0.365$, $p = 0.026$) and the duration of stay in the intensive care unit ($r = 0.332$, $p = 0.045$) (Table 14).

Table 14. The influence of preoperative indicators on the course of the postoperative period in the ministernotomy group.

Indicator	Duration of stay in intensive care unit	Ventila-tion time (h)	Amount of blood flown through drainage	Hospita-lization duration (in total)	Hospita-lization duration (since the day of surgery)	The lowest hemoglobin level after surgery	The lowest platelets level
Age	**0.268**	0.184	0.032	0.167	0.155	0.201	-0.033
p	**0.030***	0.139	0.798	0.180	0.215	0.106	0.794
BMI	-0.060	0.063	-0.077	-0.188	-0.084	-0.036	0.012
p	0.632	0.616	0.538	0.130	0.504	0.772	0.926
Hemoglobin level	0.135	0.101	-0.150	0.123	0.163	0.168	0.101
p	0.425	0.552	0.376	0.470	0.335	0.321	0.551
Creatinine level	0.302	-0.042	-0.093	**0.478**	**0.438**	0.090	-0.112
p	0.069	0.804	0.585	**0.003***	**0.007***	0.597	0.511
Bilirubin level	0.079	0.085	-0.233	-0.044	-0.019	-0.340	-0.190
p	0.640	0.618	0.165	0.797	0.910	0.040	0.259
Blood clotting	0.243	0.126	-0.239	0.226	0.213	0.235	0.176
p	0.148	0.458	0.154	0.178	0.206	0.162	0.297
Euroscore II	0.110	-0.038	0.153	0.168	0.233	0.171	0.087
p	0.518	0.823	0.367	0.320	0.165	0.311	0.609
ISTD	-0.057	-0.272	-0.084	-0.013	-0.132	-0.018	0.115
p	0.739	0.103	0.620	0.941	0.435	0.918	0.500
LVDD	0.272	0.144	-0.074	0.368	0.364	-0.056	0.056
p	0.104	0.396	0.666	0.025	0.027	0.742	0.741
LVSD	**0.332**	0.173	0.032	**0.365**	**0.354**	-0.160	-0.193
p	**0.045***	0.306	0.850	**0.026***	**0.031***	0.345	0.253
PG max	-0.013	-0.126	-0.047	0.013	-0.094	-0.032	-0.103
p	0.940	0.457	0.782	0.939	0.579	0.852	0.544
PG mean	-0.156	-0.229	-0.140	-0.203	-0.174	-0.199	-0.114
p	0.355	0.172	0.409	0.229	0.303	0.237	0.502

*$p<0.05$ – differences between the groups are significant.

Thus, we have observed that in the median sternotomy group, a much larger number of parameters influence the course of the operation and the features of the postoperative period; hence, the choice of this access should be more carefully considered by the surgeon, as preoperative indicators may significantly affect the outcome of the operation.

Under ministernotomy, the outcome of the operation depends upon a significantly smaller number of factors, which indirectly indicates that this access is favorable for most categories of patients.

The findings obtained could form the basis for the formation of new criteria for the selection of patients to perform median sternotomy or ministernotomy.

3.3. CLINICAL RESULTS OF THE IMPLEMENTATION OF MEDIAN STERNOTOMY AND MINISTERNOTOMY IN PATIENTS WITH THE PATHOLOGY OF AORTIC VALVE SUFFERING EXCESSIVE BODY MASS.

3.3.1. EVALUATION OF OPERATIONAL INDICATORS

In assessing surgery characteristics, it was marked that biological valves were significantly more frequently used in the case of ministernotomy – 48 (85.7%) versus 22 (39.3%) in the cases of a median sternotomy ($p<0.001$). The frequency of the application of valves having a certain size did not differ significantly in the two groups.

An analysis of surgery duration showed that the duration of ministernostomy was significantly longer when compared to median sternotomy; on the average, the difference was nearly 18 minutes, $p = 0.046$.

When performing a ministernotomy, a longer clamping of the aorta during the surgery was required. On average, in the main group of the patients, the aorta was clamped 15 minutes longer than in the control group patients ($p<0.001$).

During the operation, in all patients from the ministernotomy group, an antegrade cardioplegia was performed through the coronary ostium, while a combination of two types of cardioplegia – through the coronary ostium and retrograde cardioplegia – was used in the majority of patients from the median sternotomy group: 29 patients (51.8%) ($p<0.0001$).

In the case of a ministernotomy, the use of extracorporeal circulation lasted 148.3 ± 4.4 minutes, while in the case of sternotomy, it lasted 133.6 ± 2.7 minutes. Thus, on average, in the case of a ministernotomy, the duration of extracorporeal circulation is 15 minutes longer than in the case of sternotomy, $p = 0.023$.

When performing sternotomy, an intra-aortic balloon pump (IABP) was used during the course of surgery of 1 (1.8%) patient, and in the ministernotomy group, extracorporeal membrane oxygenation was conducted for 1 patient (1.8%) in two days after surgery during the reoperation. There were no cases of transition to a median sternotomy from minimal access.

Operation characteristics of the two groups of patients are presented in Table 15.

Table 15. The characteristics of surgery indicators in groups.

Indicator	**Median sternotomy (N = 56)**	**Ministerno-tomy (N = 56)**	**P**
Surgery duration (min), (mean±SD)	246.02 ± 72.31	264.91 ± 62.03	0.046*
Aortic cross-clamping time (min), (mean±SD)	76.82 ± 23.30	91.88 ± 20.713	<0.001*
Cardiopulmonary bypass time (min), (mean±SD)	133.6 ± 2.7	148.3 ± 4.4	0.023*
Bleeding during surgery, n (%) *Source – aortotomy* *Other source*	1 (1.8%) 1 (1.8%) 0 (0%)	0 (0%) 0 (0%) 0 (0%)	0.316 0.316 ---
Number of cardioplegia cycles	4.31 ± 1.27	4.05 ± 1.03	0.772
Cardioplegia duration (min)	18.14 ± 8.90	17.09 ± 6.98	0.256
Repeated cardioplegia, n(%)	1 (1.8%)	0 (0%)	0.316
Cardioplegia during surgery, n (%) *Retrograde* *Coronary mouth* *Combined*	 3 (5.4%) 24 (42.9%) 29 (51.8%)	 0 (0%) 56 (100%) 0 (0%)	 0.043* <0.001* <0.001*
Cardioplegic solution, n (%) *Pharmaco-cold cardioplegia* *Cold blood cardioplegia*	 30 (53.6%) 26 (46.4%)	 50 (89.3%) 6 (10.7%)	 <0.001* <0.001*
Aortotomy type, n (%) *Transverse aortotomy* *Hockey stick aortotomy*	 5 (8.9%) 51 (91.07%)	 26 (46.4%) 30 (53.6%)	 <0.001* <0.001*
The lowest patient's body temperature during surgery,°C	28.45 ± 2.40	28.05 ± 0.87	0.668
Valve type, n (%) *Biological* *Mechanical*	 22 (39.3%) 34 (60.7%)	 48 (85.7%) 8 (14.3%)	 <0.001* <0.001*
Aortic valve size: n (%) *19 mm* *21 mm* *23 mm* *25 mm* *27 mm* *29 mm*	 1 (1.8%) 3 (5.4%) 27 (48.2%) 23 (41.1%) 2 (3.6%) 0 (0%)	 0 (0%) 6 (10.7%) 23 (41.1%) 22 (39.3%) 5 (8.9%) 0 (0%)	 0.315 0.297 0.447 0.847 0.242 ---
ECMO, n (%)	0 (0%)	1 (1.8%)	0.315
IABP, n (%)	1 (1.8%)	0 (0%)	0.315

*p<0.05 – differences between the groups are significant.

3.3.2. EVALUATION OF POSTOPERATIVE INDICATORS

The duration of artificial lung ventilation in both groups was comparable. For ministernotomy, it was 9.38 ± 1.74 hours, and for median sternotomy – 10.3 ± 1.37 hours (p = 0.744).

The amount of blood flowing through the drain during the first 24 hours also did not differ significantly between the two groups and was 354.46 ± 31.16 ml in the median sternotomy group and 315.18 ± 28.69 in the mini invasive access group (p = 0.356).

Despite the fact that in the ministernotomy group platelets were needed for 7.14% of the patients, and in sternotomy group – for 1.8% of the patients, the differences between the groups were not statistically significant (p = 0.172).

The number of resternotomies after surgery in the two groups did not differ statistically – 3.6% after a median sternotomy and 1.8% after a ministernotomy. The reason for the resternotomies after surgery in the two groups was bleeding from an unknown source.

In the case of a ministernotomy, postoperative renal failure was significantly less common – in 2 patients (3.6%) – as compared with 12 patients in the case of a median sternotomy (21.4%) (p = 0.004). All patients from the ministernotomy group were treated with diuretics. Nine patients from median sternotomy group were treated with diuretics; hemofiltration was used for 2 patients, and hemodialysis was used for 1 patient.

The mortality rate in both groups was comparable – in the case of a sternotomy, 2 patients died (mortality – 3.6%). Mortality in the case of a ministernotomy was 1.8% – 1 patient died. All fatal outcomes have occurred after the surgery. In the case of a median sternotomy, patients died in 3 and 12 days after surgery. In the case of a ministernotomy, the patient died on the 7^{th} day.

No significant differences in hospitalization duration were found (p = 0.161). In patients from the ministernotomy group, it was 18.55 ± 1.40 days, and in patients from the control group – 22.52 ± 1.31 days. The duration of hospitalization after surgery did not differ significantly. Patients spent a comparable number of hours in an intensive care department. A left ventricular ejection fraction ≥50% at discharge was significantly greater in the sternotomy group.

The nearest postoperative outcomes are presented in Table 16.

Table 16. The characteristics of the postoperative outcomes in the groups.

Indicator	Median sternotomy (N = 56)	Ministerno-tomy (N = 56)	P
Ventilation time (h), (mean±SD)	10.03 ± 1.37	9.38 ± 1.74	0.744
Blood loss≥1000 mL/24 h, n (%)	2 (3.8%)	1 (1.8%)	0.559
24h chest tube drainage (mL), (mean±SD)	354.46 ± 31.16	315.18 ± 28.69	0.356
ICU stay (h), (mean±SD)	72.46 ± 5.81	70.79 ± 7.39	0.859
Hospitalstay,post-surgery (days), (mean±SD)	15.23 ± 1.57	13.18 ± 1.08	0.280
Hospital stay (days), (mean±SD)	22.52 ± 1.31	18.55 ± 1.40	0.161
Number of patients, who underwent red blood cells transfusion, n (%)	8 (14.3%)	12 (21.4%)	0.641
Red blood cells transfused, in total (ml)	839.38 ± 82.1	510.4 ± 79.4	0.215
Number of patients, who underwent platelets transfusion, n (%)	1 (1.8%)	4 (7.14%)	0.172
Platelets transfused, in total (ml)	120.0 ± 19.8	435.0 ± 177.4	0.881
Number of patients, who underwent fresh frozen plasma transfusion, n (%)	4 (7.41%)	1 (1.8%)	0.416
Fresh frozen plasma transfused, in total (ml)	1193.75 ± 146.17	1040 ± 97.75	0.898
Resternotomy, n (%)	2 (3.6%)	1 (1.8%)	0.539
Cardiac tamponade, n (%)	1 (1.8%)	1 (1.8%)	1.000
Stroke, n (%)	0 (0%)	0 (0%)	---
Cardiac rhythm at discharge, n (%) *Sinus rhythm* *Auricular fibrillation* *Implantation of pacemaker within the period from surgery till discharge from hospital*	 51 (91.07%) 2 (3.8%) 3 (5.4%)	 50 (89.3%) 3 (5.4%) 3 (5.4%)	 0.076 0.698 1.000
An implantation of pacemaker within the whole postoperative period, n (%)	3 (5.4%)	3 (5.4%)	1.000
Acute renal failure, n (%) *Was treated with a diuretics* *Was treated with a hemofiltration* *Was treated with a hemodialysis*	12 (21.43%) 9 (16.07%) 2 (3.6%) 1 (1.8%)	2 (3.6%) 2 (3.6%) 0 (0)% 0 (0)%	0.004* 0.427 0.205 0.53
Surgical wound infection, n (%) *Superficial wound infection - treated with antibiotic only* *Mediastinitis - treated with sternum drainage with washing*	3 (5.4%) 2 (3.6%) 1 (1.8%)	1 (1.8%) 1 (1.8%) 0 (0%)	0.647 0.089 0.316
30-day mortality, n (%)	2 (3.6%)	1 (1.8%)	0.558
Intraoperative mortality, n (%)	0 (0.0%)	0 (0%)	---
LVEF at discharge, n (%) *<30%* *30-50%* *≥50%*	 0 (0%) 12 (22.2%) 42 (77.8%)	 0 (0%) 22 (40%) 33 (60%)	 --- 0.045* 0.045*
PG max (mmHg)	32.12 ± 15.46	33.45 ± 20.42	0.461
PG mean (mmHg)	25.17 ± 7.03	25.40 ± 12.03	0.372

*p<0.05 – differences between the groups are significant.

An evaluation of drug therapy for the hemodynamic support showed that adrenaline was used significantly more often in the sternotomy group – 30.4% versus 5.4% in the ministernotomy group ($p<0.001$).

Among medicines for anesthesia in the postoperative period, morphine and non-steroidal anti-inflammatory drugs were most often used. There were no statistically significant differences in the use of morphine – 96.4% in the minimal access group and 100% in the median access group ($p = 1.00$).

Nonsteroidal anti-inflammatory drugs were reliably more frequently used in patients after a median sternotomy, 98.2% vs. 76.8% ($p<0.001$). Paracetamol was reliably more frequently used in patients from the sternotomy group, 83.9% versus 71.4% ($p<0.005$) (Table 17).

Table 17. The characteristics of drugs used in the groups.

Indicator	**Sternotomy (N = 70)**	**Ministernotomy (N = 70)**	**p**
Preparations for maintaining hemodynamic			
The number of patients treated with adrenaline, n (%)	21 (30.0%)	4 (5.71%)	<0.001*
Duration of treatment with adrenaline (hours)	27.23 ± 3.03	4.75 ± 2.75	0.314
The maximum dose of adrenaline, μg/kg/min	0.05 ± 0.001	0.05 ± 0.001	0.910
The number of patients treated with noradrenaline, n (%)	43 (61.43%)	42 (60%)	0.863
Duration of treatment with noradrenaline (hours)	37.21 ± 4.93	23.06 ± 4.06	0.236
The maximum dose of noradrenaline, μg/kg/min	0.05 ± 0.01	0.05 ± 0.01	0.913
The number of patients treated with dopamine, n (%)	5 (7.14%)	6 (8.57%)	0.753
Duration of treatment with dopamine (hours)	31.70 ± 3.40	18.33 ± 1.95	0.625
The maximum dose of dopamine, μg/kg/min	10.08 ± 2.41	6 ± 2.02	0.750
The number of patients treated with dobutamine, n (%)	6 (8.57%)	6 (8.57%)	1.00
Duration of treatment with dobutamine (hours)	34 ± 9.18	8.33 ± 1.17	0.415
The maximum dose of dobutamine, μg/kg/min	4 ± 1	4.68 ± 0.54	0.894
The number of patients treated with nitroglycerine, n (%)	4 (5.71%)	4 (5.71%)	1.00
Duration of treatment with nitroglycerine (min)	24 ± 4	9 ± 3.11	0.103
The maximum dose of nitroglycerine, μg/ min	0.44 ± 0.007	0.45 ± 0.001	0.916

Preparations for anesthesia			
Morphine, n (%)	69 (98.57%)	63 (90%)	0.029*
Tramadol, n (%)	0 (0%)	3 (4.62%)	0.080
Nonsteroidal anti-inflammatory drugs (other than paracetamol), n(%)	69 (98.57%)	55 (78.57%)	<0.001*
Paracetamol, n(%)	48 (68.57%)	54 (77.14%)	0.254

*p<0.05 – differences between the groups are significant.

Thus, we see that patients from the ministernotomy group require much less serious therapy with analgesics – that is not only good for the patients' health but also beneficial from the pharmaco-economic perspective.

In addition to standard calculations, we also included a questionnaire of patients in the clinical analysis. As a result of the survey, we have revealed an increase in patient satisfaction with treatment due to a faster return to daily activities and better cosmetic effects.

In 7 days after the surgeries, we asked the patients how many of them could perform simple actions (Fig. 8).

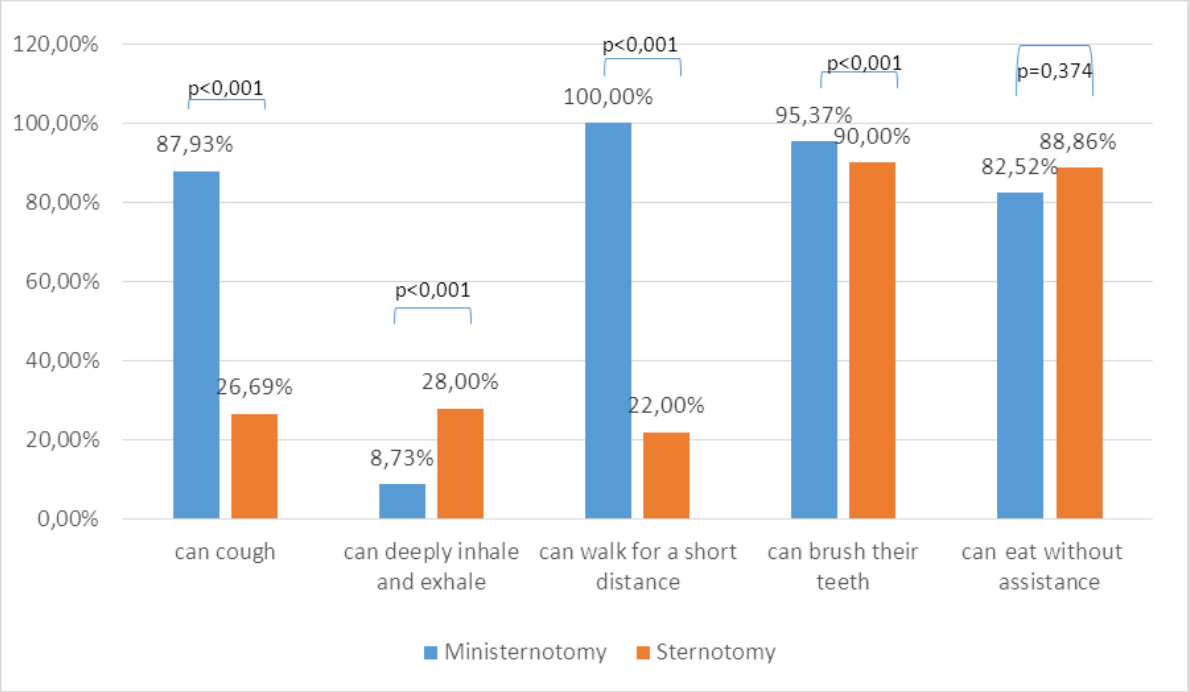

Figure 8. The ability to perform simple actions in both groups of patients.

According to the data obtained, among the patients of the main group, the ability to perform simple actions during the first week after the operation was encountered in a significantly greater number of individuals (p<0.001). Significant differences were not revealed only with

respect to food intake – in the main group, this ability was fixed in 82.52%, and in the control group – in 88.86% of the subjects (p = 0.374).

Results of the patient survey regarding the cosmetic effects of both methods are shown in Figure 9.

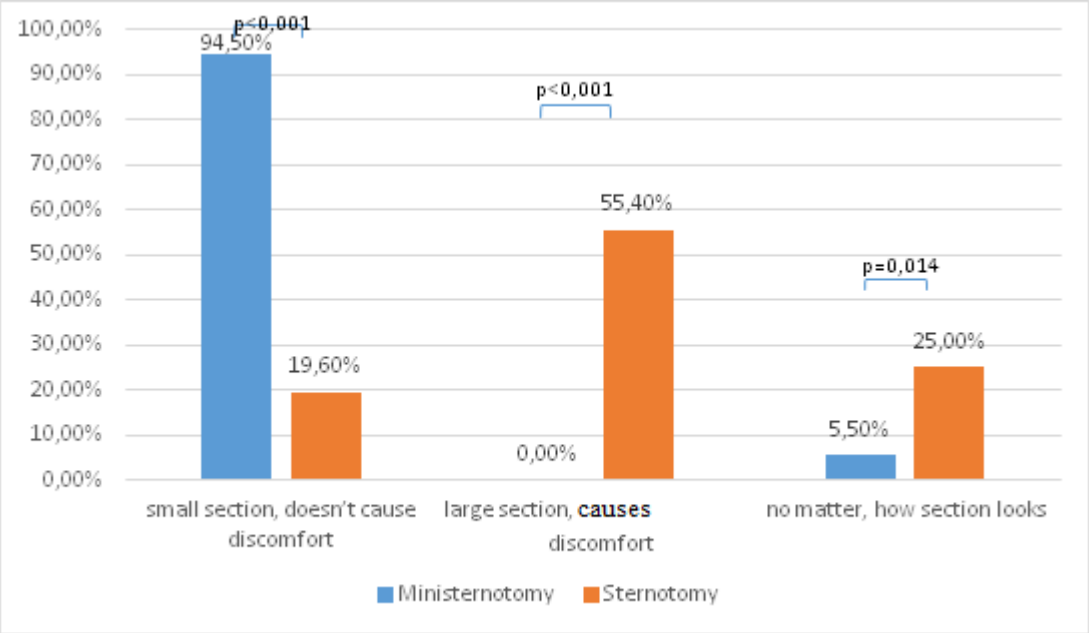

Figure 9. The opinion of patients on the postoperative section.

We detected significant differences in the number of patients satisfied with the size of postoperative wound – in ministernotomy group there were 94.5% of such patients (p<0.001). Number of patients who do not care how the incision looks like was significantly larger in median sternotomy group (p = 0.014).

To clarify the pain intensity, patients' survey was conducted using visual analog pain scale. The results are shown in Figure 10.

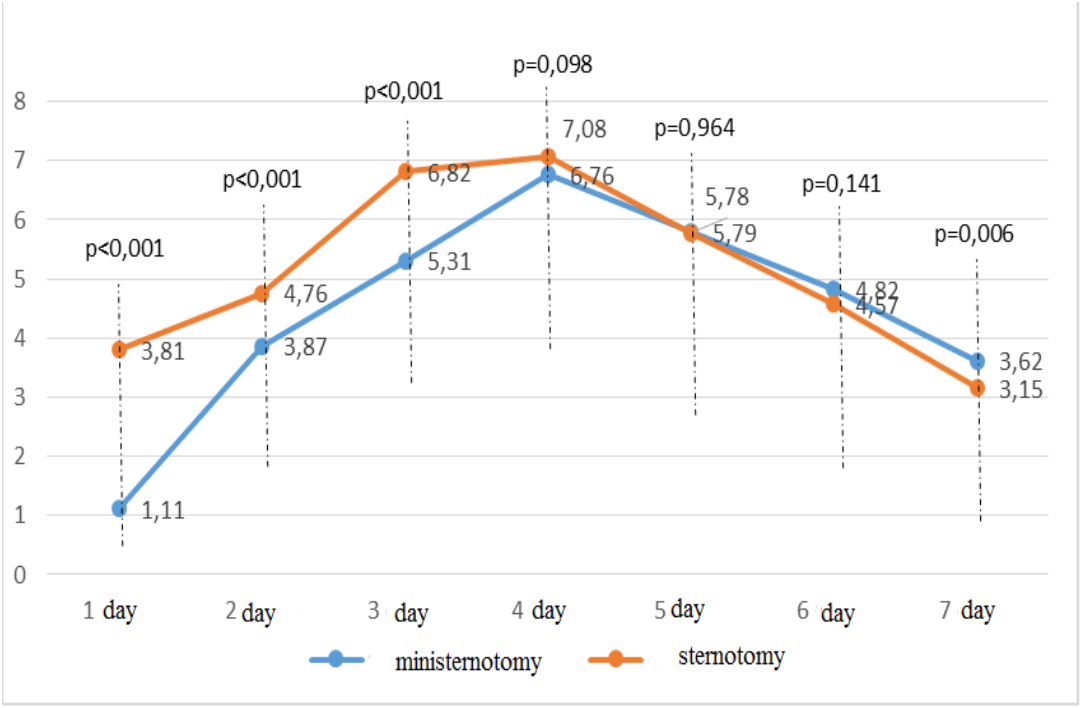

Figure 10 - Dynamic assessment of pain on a visual analog scale

As seen from the graph, at the first day after surgery symptoms of pain in patients from the ministernotomy group are minimal. Then a tendency to the increase in pain appears. On the 4th day the statistical differences in the level of pain in patients of the two groups are leveled and in the future their sensations are comparable. However, on the 7th day in median sternotomy group we observed marked reduction in pain, and as a result its level in this group became significantly lower than that in the main group – 3.15 ± 0.71 versus 3.62 ± 1.11, respectively (p = 0.006).

In addition, we have analyzed the impact of excess weight of the body on peri- and postoperative outcomes in the two groups. For main indicators we have calculated the correlation coefficient (Table 18).

As a result of the analysis, any significant correlation between the body mass index and any index in both groups have been not identified.

Table 18. The effect of the body mass index in the peri- and postoperative indicators.

Indicator	Median sternotomy		Ministernotomy	
	r^2	p	r^2	p
Surgery duration, min.	0.123	0.382	0.255	0.116
Aortic cross-clamping time, min.	0.042	0.766	0.169	0.303
The duration of cardiopulmonary bypass, min.	0.508	0.721	0.247	0.129
Ventilation time, hours	0.051	0.721	0.121	0.461
The amount of blood flowing through the drain, ml	-0.173	0.903	-0.190	0.247
ICU stay, hours	0.156	0.276	0.122	0.941
Hospitalstay,post-surgery (days),	0.089	0.530	0.205	0.211
Hospital stay (days)	.103	0.464	0.203	0.215
LVEF %, n (%) at discharge	0.209	0.136	0.007	0.965

*p<0.05 – differences between the groups are significant.

To monitor the distant results of surgery in overweight patients, the echocardiography indicators, NYHA stages and clinical symptoms have been examined within a duration of several years.

Significant differences between patients were not observed at the 30th day. Severity degrees, according to the NYHA, echocardiography indicators and clinical symptoms, were comparable (Table 19).

Table 19. The 30-day patient results.

Indicator	Median sternotomy (N = 47)	Ministernotomy (N = 42)	P
NYHA, n (%)			
I	0 (0%)	0 (0%)	---
II	34 (72.3%)	25 (59.5%)	0.202
III	13 (27.7%)	17 (40.5%)	0.202
Clinical complaints, n (%)			
Absent	34 (72.3%)	36 (85.7%)	0.679
Thoracalgia	13 (27.7%)	6 (14.3%)	0.188
Pain behind the breastbone	0 (0%)	0 (0%)	---
Dyspnea	0 (0%)	0 (0%)	---
Sleep disturbances	0 (0%)	0 (0%)	---
LVEF %, n (%)			
<30%	0 (0%)	0 (0%)	---
30-49%	15 (31.9%)	7 (16.7%)	0.217
>50%	32 (68.1%)	35 (83.3%)	0.541
PG max (mmHg)	29.90 ± 11.12	32.82 ± 13.58	0.267
PG mean (mmHg)	18.5 ± 5.50	19.47 ± 6.52	0.562

*p<0.05 – differences between the groups are significant.

The 90th day results showed a significant predominance of patients with no clinical complaints in the group of patients who underwent minimally invasive access. No other differences have been identified neither in NYHA severity nor in echocardiography indicators (Table 20).

Table 20. The 90-day patient results.

Indicator	**Median sternotomy (N = 46)**	**Ministernotomy (N = 42)**	**P**
NYHA, n (%)			
I	0 (0%)	1 (2.38%)	0.293
II	32 (27.7%)	34 (80.95%)	0.771
III	14 (72.3%)	7 (16.66%)	0.085
Clinical complaints, n (%)			
Absent	28 (60.87%)	34 (80.95%)	0.039*
Thoracalgia	4 (8.69%)	3 (7.14%)	0.788
Pain behind the breastbone	1 (2.2%)	1 (2.4%)	0.948
Dyspnea	8 (17.4%)	3 (7.14%)	0.147
Edema	1 (2.2%)	0 (0%)	0.337
Palpitation	4 (8.7%)	1 (2.4%)	0.201
LVEF %, n (%)			
<30 %	0 (0%)	0 (0%)	---
30-50 %	17 (36.9%)	5 (11.9%)	0.167
>50 %	29 (63.1%)	37 (88.1%)	0.275
PG max (mmHg)	26.39 ± 9.72	29.69 ± 10.76	0.133
PG mean (mmHg)	18.51 ± 6.43	17.76 ± 5.77	0.738

*$p<0.05$ – differences between the groups are significant.

In a year after surgery, the number of patients with no complaints was significantly higher in the ministernotomy group. Also, in the control group, such complaints as dyspnoea were more common, but despite the fact that these complaints were not met in the main group, the differences between the groups did not reach any statistical significance. The parameters of the left ventricular ejection fraction in the two groups did not differ significantly (Table 21).

Table 21. The 360-day patient results.

Indicator	Median sternotomy (N = 44)	Ministernotomy (N = 46)	P
NYHA, n (%)			
I	20 (45.5%)	19 (41.30%)	0.286
II	17 (38.6%)	27 (58.70%)	0.202
III	7 (15.90%)	0 (0%)	0.157
Clinical complaints, n (%)	(n = 43)	(n = 36)	
Absent	38 (88.37%)	35 (97.2%)	0.002*
Thoracalgia	2 (4.65%)	1 (2.8%)	0.188
Pain behind the breastbone	0 (0%)	0 (0%)	---
Dyspnea	3 (6.98%)	0 (0%)	0.070
Sleep disturbances	0 (0%)	0 (0%)	---
LVEF %, n (%)	(n = 42)	(n = 35)	
<30%	0 (0%)	0 (0%)	---
30-50%	7 (16.7%)	2 (5.7%)	0.247
>50%	35 (83.3%)	33 (94.3%)	0.251
PG max (mmHg)	30.8 ± 11.12	32.82 ±13.58	0.267
PG mean (mmHg)	18.5 ± 5.50	19.35 ± 6.52	0.562

*p<0, 05 – differences between groups are significant;

In the second year after the operation, in 100% of cases, clinical complaints were absent in the ministernotomy group. Echocardiography and NYHA groups were comparable in terms of the indices (Table 22).

Table 22. The 720-day patient results.

Indicator	Median sternotomy (N =44)	Ministernotomy (N = 55)	P
NYHA, n (%)	(n = 38)	(n = 55)	
I	30 (78.95%)	41 (74.54%)	0.760
II	8 (21.05%)	14 (25.46%)	0.760
III	0 (0%)	0 (0%)	---
Clinical complaints, n (%)	(n = 43)	(n = 52)	
Absent	41 (95.4%)	52 (100%)	0.202
Thoracalgia	0 (0%)	0 (0%)	---
Pain behind the breastbone	0 (0%)	0 (0%)	---
Dyspnea	0 (0%)	0 (0%)	---
Sleep disturbances	2 (4.6%)	0 (0.0%)	0.202
LVEF %, n (%)	(n = 42)	(n = 34)	
<30%	0 (0%)	0 (0%)	---
30-50%	17 (40.5%)	2 (5.9%)	0.347
>50%	25 (59.5%)	32 (94.1%)	0.298
PG max (mmHg)	30.8 ± 11.12	32.82 ± 13.58	0.221
PG mean (mmHg)	20.80 ± 5.71	21.75 ± 3.53	0.573

*p<0, 05 – differences between groups are significant

In the third year after the operation, we found no statistically significant differences between the groups – neither in clinical picture nor in echocardiography results (Table 23).

Table 23. The 3rd year patient results.

Indicator	Median sternotomy (N = 44)	Ministernotomy (N = 55)	P
NYHA, n (%)	(n = 30)	(n = 55)	
I	26 (86.7%)	48 (87.27%)	1.000
II	4 (13.3%)	7 (12.73%)	1.000
III	0 (0%)	0 (0%)	---
Clinical complaints, n (%)	(n = 32)	(n = 20)	
Absent	32 (100%)	20 (100%)	1.000
Thoracalgia	0 (0%)	0 (0%)	---
Pain behind the breastbone	0 (0%)	0 (0%)	---
Dyspnea	0 (0%)	0 (0%)	---
Sleep disturbances	0 (0%)	0 (0%)	---
LVEF %, n (%)	(n = 30)	(n = 30)	
<30%	0 (0%)	0 (0%)	---
30-50%	3 (10%)	0 (0%)	0.155
>50%	27 (90%)	30 (100%)	0.155

*p<0, 05 – differences between groups are significant;

When assessing survival using the Kaplan-Meier method, it was noted that the five-year survival of patients from the ministernotomy group was 92.86%, and for the patients in the median sternotomy group, it amounted to 82.14%. A reliability evaluation by means of a log-rank test showed no significant difference: p = 0.269 (Figure 11).

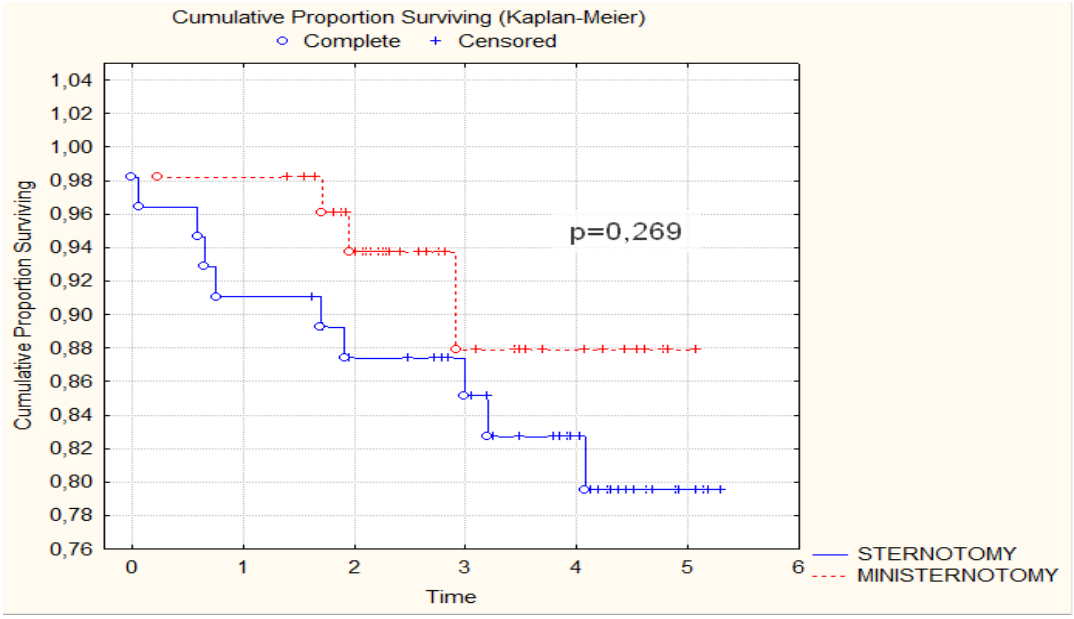

Figure 11. Kaplan-Meier curves.

Thus, ministernotomy in patients with obesity is a sufficiently safe operation that allows for performing complex surgical interventions on the aortic valve. Since its main outcomes are comparable to those for median sternotomy, and the proportion of patients who are satisfied with the treatment results is higher and the postoperative complications, such as renal insufficiency after ministernotomy, were significantly less frequent, we believe that this method of access can be recommended as the preferred one for aortic valve replacement in patients who are overweight.

CONCLUSION

The experience of using mini-access in prosthetic surgery has been around for more than 20 years, but discussions about the appropriateness and safety of this technique continue until now despite the large number of scientific papers devoted to this topic.

Despite the fact that many authors tend to favor mini-sternotomy when choosing access, within the literature, one can quite often find very inconsistent data on the advantages of one or the other kind of access. That is why our study was designed to detail the available data. As a result, we did notice some technical points due to which ministernotomy gives way to median access. In particular, these are prolonged aortic cross-clamping and the longer time of artificial circulation, but we concluded on the basis of the data that these features do not affect the early postoperative period and the frequency of complications. Therefore, this method is not inferior in terms of security to median access. In addition, ministernotomy is associated with a smaller level of traumatism, as evidenced by the lower blood volume flowing through the drainage, and, accordingly, a reduced need for a medicamentous correction of coagulopathy and analgesics, a faster recovery of patients and the reduced duration of hospitalization.

Another aspect to which we paid attention at the beginning of the the study was the lack of a sufficient number of studies that reveal the detailed nuances of the course of the early postoperative period and, especially, the long-term periods of the observation of patients or their study based on individual indicators. Therefore, our tasks included a complex study of these aspects. As a result, in a number of studies, including the study of 5-year survival, it was noted that in the long-term follow-up of the vast majority of indicators, ministernotomy is comparable to traditional intervention, and that this is more in favor of the first technique.

The study of the peculiarities of using ministernotomy in a particular groups of patients – with overweight patients, in our instance – has shown that the use of this kind of access is also associated with a decrease in the frequency of complications and the best subjective feelings of

patients both immediately after the operation and in the long observation period. That is why mini-invasive access should be recommended as the main kind of access in such patients.

Another point in favor of ministernotomy was that the study of preoperative factors affecting the outcome of the operation demonstrated a lesser level of dependence of ministernotomic results on the initial data, which also makes it the operation of choice. It turns out that ministernotomy use is more justified under many equal conditions.

Thus, ministernotomy can be recommended as a priority operation for aortic valve replacement.

FINDINGS

1. An aortic valve replacement using the ministernotomic approach is as safe and effective as a surgical intervention using the median sternotomy approach.

2. An aortic valve replacement using the ministernotomic approach requires a longer aorta clamp duration and an increased duration of artificial circulation as compared to the median sternotomic approach.

3. Patients of the ministernotomy group required statistically significantly shorter duration of artificial lung ventilation, lower dosage of drugs for coagulopathy correction, as well as adrenalin and morphine; they lost less blood oozing through drains, stayed shorter in an intensive care unit and required transfusion of lower volumes of the red blood mass and fresh-frozen plasma.

4. For patients, who underwent surgery using the ministernotomy approach, the early post-operative period is characterized by the statistically better cosmetic result, less pain in the first 7 days after surgery, early rehabilitation, fewer postoperative complications, shorter stay in hospital and less frequent necessity to prescribe nonsteroidal anti-imflammatory drugs.

5. For patients, who underwent surgery using the ministernotomy approach, the long-term post-operative period is characterized by the statistically higher number of patients with no complaints within a year after surgery. Upon 30 and 90 days, as well as 2 and 3 years after surgery, there were no significant differences between groups. During the said periods, there were no new cardiac interventions performed. Rate of survival of patients in the ministernotomy group was 91.4%, while in the sternotomy group - 97.1%, however, no significant difference was found out between groups.

6. As a result of a correlation analysis, it was found out that a lot more preoperative indices in patients from the sternotomy group were linked to the process of surgery and the peculiarities of the postoperative period. Those indices include age, blood coagulability, Euroscore, maximum and average gradient, haemoglobin and creatinine levels. In the ministernotomy group, a lower number of factors have had impact on the results of surgery; this indirectly proves that the approach in question is more suitable for a larger category of patients.

7. As a result of an analysis of homogenous patients who were overweight, it was found out that postoperative indices in patients after ministernotomies were better, namely:

a. A decreased risk of acute renal failure;

b. Better subjective sensations for patients after surgery;

c. A statistically higher number of patients in the ministernotomy group have no complaints upon 90 and 360 days after surgery;

d. A better cosmetic result;

e. A smaller demand in drug therapy for haemodynamic support and less consumption of painkillers.

8. Based on the results of an analysis of links between overweight with the process of surgery and postoperative results, it was found that there is no significant correlation between the body-weight index and any of indices.

PRACTICAL RECOMMENDATIONS

1. In the presence of equal clinical situations in patients and in the absence of contraindications to the implementation of ministernotomy or median sternotomy, ministernotomy should be considered a priority when choosing the technique of conducting an operation.

2. Due to a number of advantages over median access surgery, ministernotomy should be recognized as an operation of choice in patients with an aortic valve pathology in the presence of obesity.

3. An analysis of correlation relationships demonstrated that the course of surgery in the ministernotomy group is less dependent on age; therefore, we recommend that this intervention be carried out not only, for example, for the elderly (as they are patients at risk) but for younger age groups as well.

BRIEF INFORMATION ABOUT THE AUTHOR

1993–1999	Medical General Practice.
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PUBLICATIONS AND PRESENTATIONS AT CONFERENCES

PUBLICATIONS

1. Aliahmed HMA, Podkopajev A, Samėnienė P. Comparison of results of aortic valve replacement through median sternotomy and mini sternotomy in overweight patients. *Lietuvos chirurgija* 2017; 16 (3–4):183–187.

2. Aliahmed HMA, Karalius R, Valaika A, Grebelis A, Samėnienė P, Čypienė R. Efficacy of Aortic Valve Replacement through Full Sternotomy and Minimal Invasion (Ministernotomy). *Medicina* 2018; 54(2): 26. DOI: 10.3390/medicina54020026.

Presentations

1. Aliahmed H. The efficacy and safety of ministernotomy for correction of aortic valve disease in patients with overweight. *The 12th International Congress of Update in Cardiology and Cardiovascular Surgery (UCCVS)*, Antalya, Turkey, March 10–13, 2016.

2. Aliahmed H. Comparison of the results of operations for aortic valve replacement techniques median sternotomy and minimal invasion (ministernotomy). *The 7th Joint Scandinavian Conference in Cardiothoracic Surgery*, Bergen, Norway, September 3–5, 2015.

SUMMARY IN LITHUANIAN

Santrauka

ĮVADAS

Tiriamoji problema, darbo aktualumas ir reikšmė

Pastaraisiais dešimtmečiais labai padidėjo aortos vožtuvų patologijos dažnis, o tai paskatino ieškoti tausojančių chirurginio gydymo metodų. Tad 1996 metais chirurgų arsenale atsirado nauji minimaliai invaziniai būdai (viršutinė ir apatinė ministernotomija, V formos, Z formos, T formos, J formos ir kt. ministernotomija). Nauji metodai sudarė sąlygas pagerinti gydymo rezultatus, sumažinti komplikacijų dažnį, palyginti su tradicine vidurine sternotomija, tačiau vis dar aktualus išlieka klausimas, kiek iš tikrųjų šie metodai yra geresni už tradicinę sternotomiją.

Pagal intraoperacinius veiksnius operacijos technika nesiskiria nuo standartinei sternotomijai taikomų metodų. Tiek sternotomijos, tiek ministernotomijos pjūviams gali būti naudojami tie patys instrumentai, tačiau atliekant ministernotomiją ypač svarbu kruopščiai praskirti krūtinkaulio kraštus, antraip bus neišvengta krūtinkaulio lūžio prie apatinio pjūvio krašto. Siekiant tinkamai praskirti krūtinkaulio kraštus, naudojamas nedidelis šonkaulių skėtiklis Tuffier, o atliekant įprastinę vidurinę sternotomiją – standartinis torakalinis žaizdų skėtiklis.

Pripažinta, kad aortos vožtuvo keitimas dirbtinės kraujotakos sąlygomis, atliekant vidurinę sternotomiją, užtikrina geriausią prieigą prie širdies, tačiau kartu yra susijęs su didesne sužalojimų tikimybe, kraujavimo rizika ir tolesnio mediastinito vystymusi. Be to, dėl stipraus skausmo sindromo ankstyvuoju pooperaciniu laikotarpiu prireikia nevienkartinio narkotinių analgetikų vartojimo net ir ligonį išrašius į namus, dėl kvėpavimo mechanikos pažeidimo gali išsivystyti kvėpavimo nepakankamumas. Kita vertus, įrodyta, kad minimalios invazijos būdai leidžia sumažinti netenkamo kraujo kiekį, infekcijos išsivystymo tikimybę ir hospitalizacijos trukmę, pagerina kosmetinį rezultatą ir pagreitina paciento gijimą.

Tačiau kai kurie autoriai atkreipia dėmesį ne tik į mini sternotomijos privalumus, bet ir jos trūkumus: ilgesnį pačios operacijos atlikimo laiką, ilgesnį aortos skersinio gnybto uždėjimo laiką ir didesnę dirbtinės kraujotakos taikymo trukmę. Tai yra ypač aktualu rizikos grupei priskiriamiems pacientams, kuriems šie veiksniai gali turėti daug įtakos operacijos rezultatams ir tolesnei savijautai.

Kaupiantis chirurginei patirčiai, visos pirmiau nurodytos problemos gali būti išsprendžiamos. Ministernotomijos rezultatai bus vis geresni, vis sumaniau pasitelkiant minimalios invazijos metodo pranašumus. Todėl kiekvienos klinikos patirtis yra įdomi ir reikšminga.

Nors yra atlikta nemažai tyrimų siekiant palyginti vidurinės (standartinės) sternotomijos rezultatus su minimaliai invazyviu metodu, visi jie iš esmės skirti pačios operacijos niuansams aptarti. Nepakankamai dėmesio skiriama dviejų grupių pacientų medikamentinių preparatų poreikio tyrimui, pooperacinio laikotarpio eigos ypatybėms ir fiziologinių funkcijų atkūrimui. Be to, atliekant šiuolaikinius tyrimus labiausiai akcentuojami trumpalaikiai rezultatai, nors iš tikrųjų būtina atsižvelgti į operacijos metodo įtaką vėlyviesiems rezultatams ir ligonių išgyvenamumui, o tai jau yra ateities tyrimų tema. Taigi turimus rezultatus būtina detaliau išanalizuoti pasitelkiant išsamų minimalios ir vidurinės prieigos operacijų palyginimą, atskleidžiantį ne tik pačios operacijos eigos ypatumus, bet ir visus pooperacinio laikotarpio bei tolesnio stebėjimo subtilumus. Be to, dauguma pastaruoju metu atliktų tyrimų pasižymi tuo, kad juose nagrinėjami atskiri gydymo aspektai – arba operacijos eiga, arba ankstyvieji pooperaciniai, arba vėlyvieji rezultatai. Tačiau iš tikrųjų būtina atlikti kompleksinius tyrimus, atsižvelgiant į visus šiuos veiksnius, nes tik visapusiškai išnagrinėjus klausimą bus galima nustatyti vienos ar kitos metodikos privalumus.

Būtina atkreipti dėmesį, kad optimalios prieigos pasirinkimas yra susijęs ne tik su medicininiais, bet ir socialiniais bei ekonominiais aspektais, nes po operacijos atsirandančios specifinės komplikacijos labai pablogina gydymo rezultatus ir dažnai lemia ilgalaikį neįgalumą, o tokiems ligoniams gydyti reikia papildomų finansinių išteklių.

Dar vienas svarbus aspektas – tai būtinybė tikslinti, kokiu atveju taikytina viena ar kita prieiga. Tobulėjant operacijų technikai, keičiasi ir ligoniams tinkamos metodikos parinkimo principai. Tai ypač akivaizdu analizuojant rizikos grupei priskiriamus pacientus. Pavyzdžiui, dar visai neseniai antsvoris buvo kontraindikacija atlikti minimaliai invazyvias operacijas. Tačiau pastaruoju metu šis požiūris buvo peržiūrėtas, nes atlikti tyrimai parodė, kad nutukusių pacientų operacijos minimali prieiga yra siejama su mažesne operacine trauma, mažesniu pooperacinių komplikacijų skaičiumi ir greitesniu pacientų gijimu.

Todėl būtina sukurti naujus pacientų, kuriems galima atlikti ministernotomiją, atrankos principus. Kadangi trūksta duomenų apie vėlyvuosius operacinių intervencijų rezultatus, reikia atlikti papildomus tyrimus.

Kuriant tokio pobūdžio pacientų atrankos strategiją, reikėtų atkreipti dėmesį į prieš operaciją nustatytų antropometrinių, klinikinių ir laboratorinių rodiklių įtaką skirtingais metodais atliekamos chirurginės intervencijos eigai ir ankstyvojo pooperacinio laikotarpio ypatumams, juolab kad tokie tyrimai yra tik pavieniai. Siekiant pasirinkti tinkamiausią intervenciją, labai

svarbu išsamiai ir detaliai palyginti minimaliai invazyvia ir tradicine metodika atliktų operacijų ankstyvuosius ir vėlyvuosius rezultatus.

Tyrimo tikslas

Įvertinti ir palyginti aortos vožtuvo keitimo operacijų rezultatus, taikant vidurinės sternotomijos ir minimalios invazijos (ministernotomijos) metodus.

Darbo uždaviniai:

1. Įvertinti ministernotomijos efektyvumą ir saugumą keičiant aortos vožtuvą pacientams, turintiems aortos vožtuvo patologiją, ir palyginti su vidurine (standartine) sternotomija.

2. Atlikti grupių pacientų aortos vožtuvo keitimo operacijos ypatumų lyginamąją analizę, kai taikoma ministernotomija ir vidurinė sternotomija.

3. Atlikti ministernotomijos ir sternotomijos grupių pacientų pooperacinių rodiklių lyginamąją analizę, kai rodikliai yra vertinami pacientų gydymo reanimacijos skyriuje laikotarpiu.

4. Ištirti ankstyviausius pooperacinius klinikinius rezultatus, įskaitant susidariusių komplikacijų dažnį, skausmo pojūčius, pajėgumą atlikti paprastus veiksmus ir hospitalizacijos trukmę.

5. Ištirti lyginamų grupių pacientų vėlesnius klinikinius rezultatus.

6. Įvertinti prieš operaciją ištirtų pacientų antropometrinių, klinikinių ir laboratorinių rodiklių įtaką chirurginės intervencijos eigai ir ankstyvojo pooperacinio laikotarpio ypatumams, kai taikoma mininimali ir vidurinės sternotomijos prieiga.

7. Atlikti antsvorio turinčių pacientų aortos vožtuvo keitimo operacijų, taikant minimalią ir vidurinę sternotomijos prieigą, charakteristikų lyginamąją analizę, įvertinti abiejų grupių pacientų ankstyvuosius ir vėlyvuosius rezultatus.

8. Įvertinti antsvorio poveikį dviejų aptariamų grupių pacientų operacijos ir pooperaciniams rezultatams.

Tyrimo mokslinis naujumas

Novatoriškumu pasižymi visų galimų prieigos būdų poveikio paciento sveikatai kompleksinis tyrimas.

Darbo rezultatai išsamiai atskleidžia pacientų, kuriems taikyta minimali ir vidurinė prieiga, operacijų eigą ir ankstyvojo pooperacinio laikotarpio ypatumus. Ištirtos ne tik visuotinai priimtos

charakteristikos, bet ir preparatų poreikis skirtingoms grupėms, gijimo laikotarpio eiga, subjektyvūs paciento pojūčiai.

Darbe pateiktas ypač išsamus klinikinių charakteristikų ir echokardiografijos rodiklių kitimo per trejų metų laikotarpį įvertinimas, charakterizuojantis pacientų širdies ir kraujagyslių sistemos funkcinę būklę ir bendrą savijautą, o tai reikšmingai papildo kitus darbus, kuriuose nebuvo siekiama taip išsamiai apibūdinti šių pacientų pooperacinio laikotarpio eigos.

Koreliacinės analizės būdu įvertintas pacientų, kuriems buvo taikyta minimali ir vidurinė prieiga, priešoperacinių veiksnių poveikis, atsižvelgiant į chirurginės intervencijos eigą ir ankstyviausio pooperacinio laikotarpio ypatumus, o tai gali padėti sukurti naujus vieno ar kito tipo operacijų pasirinkimo kriterijus, priklausomai nuo pradinių paciento charakteristikų.

Praktinė darbo reikšmė

Praktinė šio darbo reikšmė yra ta, kad gautus rezultatus galima pritaikyti kardiologijos ir kardiochirurgijos skyriuose aortos vožtuvo patologiją turinčių pacientų gydymui optimizuoti, siekiant sumažinti chirurginių intervencijų sukeliamą mirtingumą ir sutrumpinti hospitalizavimo trukmę.

Atliktas darbas atskleidė pagrindines ankstyvojo ir vėlyvojo laikotarpio problemas, iškylančias pacientams, kuriems atlikta vidurinė sternotomija ir ministernotomija. Paaiškėjo, kad ministernotomijos poveikis yra labiau tausojantis, todėl ši prieiga rekomenduojama kaip prioritetinis invazijos būdas, kai nustatoma aortos vožtuvo patologija.

Vieno ar kito operacijos metodo pasirinkimo kriterijų tikslinimas atsižvelgiant į pradines paciento charakteristikas leidžia išplėsti ministernotomijos taikymo indikacijas.

Įrodyta, kad ministernotomijos prieigos operacijos ne tik leidžia greičiau grįžti į kasdienį gyvenimą, bet ir lemia palankesnius klinikinius rezultatus bei, tikėtina, pasižymi didesniu ekonominiu efektyvumu dėl trumpesnės hospitalizacijos ir mažesnio kiekio suvartojamų vaistų.

TIRIAMIEJI IR TYRIMO METODAI

Įtraukimo į tyrimą kriterijai – tik izoliuota aortos vožtuvo patologija.

Pašalinimo iš imties kriterijai:

- Daugelio vožtuvų ydos;
- Įgytos širdies ydos, reikalaujančios korekcijos kartu su AŠ;
- Pacientų amžius < 18 metų;

Tyrimas atliktas nuo 2011 m. sausio 1 d iki 2016 m. sausio 1 d Vilniaus universiteto ligoninėje Santaros klinikose. Tyrimui atlikti gautas Vilniaus regioninio biomedicininių tyrimų etikos komiteto leidimas Nr. 158200-14-715-235.

Tai retrospektyvusis tyrimas pacientų, kuriems buvo atliktas izoliuotas aortos vožtuvo keitimas, pasitelkus sternotomijos arba ministernotomijos metodus. Iš viso buvo ištirti 426 pacientai, kuriems diagnozuota aortos vožtuvo patologija. Jų amžius vyravo nuo 18 iki 88 metų. 70 pacientų buvo atlikta ministernotomija, o 356 pacientams – vidurinė sternotomija. Visos operacijos buvo atliktos nuo 2011 m. sausio 1 d iki 2016 m. sausio 1 d Vilniaus universiteto ligoninėje Santaros klinikose. Duomenys surinkti iš ligos istorijų, chirurginių ir anesteziologinių protokolų, ambulatorinių kortelių.

Pirmame tyrimo etape buvo išanalizuoti 140 intervencijų, atliktų dėl aortos vožtuvo keitimo turintiems sergantiesiems, rezultatai. Antrajame tyrimo etape buvo išanalizuoti 102 intervencijų, atliktų keičiant aortos vožtuvą antsvorio turintiems sergantiesiems, rezultatai

Remiantis panašiausių atvejų analizės metodu (angl. propensity score matching (PSM)), pacientai, panašiai pasiskirstę pagal lytį, amžių, kūno masės indeksą, pagrindinę diagnozę, ligos etiologiją, NYHA vertinimą ir pagal echokardiografijos rezultatus prieš operaciją.

Pagrindinės grupės pacientams buvo atliekamos šio tipo intervencijos: J-mini-sternotomija 44,3%, W-mini-sternotomija 21,4% ir dalinė sternotomija 34,3%.

STATISTINĖ ANALIZĖ

Statistinis gautų duomenų apdorojimas buvo atliekamas pasitelkus dispersinę analizę, naudojantis IBM SPSS 20.0 (IBM Corp, NY, USA), „Statistica 12“ (Stat soft, Tulsa, OK, USA) programomis bei R „party“ ir „rpart“ programiniais paketais.

Duomenų normaliojo pasiskirstymo vertinimas buvo atliekamas naudojant Liliforso (Lilliefors) kriterijų, kuris parodė, kad duomenys nėra pasiskirstę normaliai, todėl gautiems rezultatams apdoroti buvo taikomi neparametriniai statistikos metodai. Kruskalo ir Voliso (Kruskal–Wallis) kriterijus buvo naudojamas siekiant patikrinti medianų skirtumus, o dviejų grupių skirstiniams palyginti buvo pasitelktas Mano ir Vitnio (Mann–Whitney) U testas.

Siekiant atlikti požymių priklausomumo analizę dviejose nepriklausomose tyrimo objektų grupėse ir patikrinti nulinę statistinę hipotezę, buvo taikomi Mantelio ir Hencelio (Mantel–Haenszel) chi kvadrato kriterijus ir tikslusis Fišerio (Fisher) kriterijus (mažiems skaičiams su binominiu pasiskirstymu, jeigu stebėjimų skaičius viename ar keliuose lentelės 2x2 langeliuose buvo ≤ 5).

Chi kvadratas buvo skaičiuojamas pagal formulę

$$\chi^2 = Z^2 = \frac{(n-1)(ad-bc)^2}{n_1 n_0 m_1 m_0}$$

čia: a – skaičius subjektų, kuriems nustatytas ekspozicijos faktorius ir požymis; b – skaičius subjektų, kuriems nustatytas ekspozicijos faktorius ir nenustatytas požymis; c – skaičius subjektų, kuriems nenustatytas ekspozicijos faktorius ir nustatytas požymis; d – subjektų skaičius, kuriems nenustatytas ekspozicijos faktorius ir nenustatytas požymis.

Kriterijaus statistika atitinka Pirsono (Pearson) pasiskirstymą su laisvės laipsniais df=(1-r)(1-c). Gautos reikšmės lyginamos su kritinėmis sritimis ir daroma išvada apie faktorių tarpusavio ryšį arba jo nebuvimą.

Apdorojant tyrimo duomenis, išgyvenamumas įvertintas taikant Kaplano ir Mejerio (Kaplan–Meier) metodą, grupėms palyginti naudotas logaritminio rango (log-rank) kriterijus.

Lentelėse duomenys nurodyti kaip reikšmių vidurkiai ir standartinė paklaida (M±m).

Gauti rezultatai buvo vertinami pagal p reikšmę (p-value) – tai tikimybė, kad gaunamas tyrimo rezultatas yra atsitiktinis. Reikšmė p parodo skirtumų tarp grupių statistinę reikšmę. Įprastai reikšmingumo lygmuo yra $p \leq 0,05$.

REZULTATAI

Lyginant operacijos rodiklius tiriamųjų grupėse, pastebėta, kad mini-sternotomijos trukmė, lyginant su vidurinės sternotomija, yra vidutiniškai 7 minutėmis ilgesnė, tačiau statistiškai reikšmingai nesiskiria (p=0,856). Buvo nustatyta, kad mini-sternotomijos atlikimo metu reikėjo beveik 8 minutėmis ilgiau taikyti aortos užspaudimą operacijos eigoje (p=0,007). Mini-sternotomijai atlikti taip pat reikėjo ilgiau taikyti ekstrakorporinę kraujotaką – ji tęsėsi beveik 12 minučių ilgiau nei atliekant vidurinės sternotomiją (p=0,049). Statistiškai reikšmingi skirtumai yra susiję su pakartotinės kardioplegijos skaičiumi, vidurinės sternotomijos grupėje ji buvo atlikta 3 (4,3%) pacientams, kai mini-sternotomijos grupėje ji nebuvo atlikta nei vienam pacientui (p=0,042).

Vertinant pooperacinius rodiklius, paaiškėjo, kad mini-sternotomijos grupės pacientams prireikė ženkliai trumpesnės trukmės dirbtinės plaučių ventiliacijos nei sternotomijos grupės pacientams - 9,7±1,7 val. ir 11,7±1,4 val, (p<0,001) atitinkamai. Taip pat buvo nustatyta, kad pirmąsias 24 valandas po operacijos mini-sternotomijos grupėje per drenažą prateka mažesnis kraujo kiekis, lyginant su pilnos prieigos grupės pacientais. Po mini-sternotomijos reikšmingai mažesniam pacientų skaičiui reikėjo taikyti medikamentinę koagulopatijos korekciją.

Bendras hospitalizacijos laikas pilnos prieigos grupėje buvo beveik 4 dienomis ilgesnis (p=0,012). Tikėtina, kad trumpesnė hospitalizacijos trukmė yra vienas iš pagrindinių daugumos minimalios invazijos metodikų privalumų.

Lyginant pooperacinių komplikacijų, tokių kaip pooperacinės žaizdos infekcija, prieširdžių virpėjimas, širdies tamponavimas, emobolija, ūmus inkstų nepakankamumas, pasireiškimo dažnį – reikšmingų skirtumų tarp grupių nebuvo aptikta. Mirtingumas abiejose grupėse statistiškai reikšmingai nesiskyrė. Mini-sternotomijos grupėje mirė 1 pacientas (1,4%), o vidurinės sternotomijos grupėje mirties atvejų nebuvo užfiksuota.

Skausmo intensyvumo analizė, naudojantis vizualine analogine skale (angl. Visual Analog Scale), po atliktos mini-sternotomijos ir tradicinės operacijos atskleidė mini-sternotomijos privalumus tik pirmosiomis keliomis dienomis po operacijos. Remiantis apklausos duomenimis, taip pat nustatytas pacientų pasitenkinimo gautu gydymu didėjimas dėl greitesnio grįžimo prie kasdieninės veiklos ir geresnio kosmetinio rezultato.

Be to, buvo atskleistas įdomus faktas, kad praėjus metams po operacijos, mini-sternotomijos grupės pacientų, nepateikusių skundų, susijusių su pagrindiniu susirgimu ir chirurgine intervencija, skaičius buvo ženkliai didesnis, tačiau atsižvelgiant į tolimesnį kelių metų laikotarpį, šis skirtumas nebebuvo statistiškai reikšmingas.

Lyginant šią minimaliai invazinę metodiką su vidurinės sternotomija, kai atliekamas aortos vožtuvo keitimas pacientams, pasižymintiems antsvoriu, buvo pastebėta, kad mini-sternotomijai atlikti reikia daugiau laiko ir tai sąlygoja ilgesnį aortos užspaudimo laiką operacijos eigoje ir didesnę dirbtinės kraujotakos trukmę.

Remiantis šio tyrimo duomenimis, žaizdos infekcijos bei daugelio kitų komplikacijų dažnis, ženkliai nesiskyrė dviejose grupėse, tačiau taikant minimalios invazijos prieigą, stebima komplikacijų skaičiaus mažėjimo tendencija. Be to, atlikus mini-sternotomiją, užfiksuota beveik 6 kartus mažiau tokių komplikacijų, kaip ūmus inkstų nepakankamumas, pasitaikymo dažnis, o tai turi didelę įtaką paciento gerbūviui ateityje.

Medikamentinės terapijos hemodinamikai palaikyti įvertinimas parodė, kad adrenalinas ženkliai dažniau vartojamas vidurinės sternotomijos grupėje (p<0,001). Nesteroidiniai priešuždegiminiai preparatai statistiškai reikšmingai dažniau buvo skiriami pacientams po vidurinės sternotomijos (p<0,001). Paracetamolio vartojimas taip pat buvo dažniau skiriamas sternotomijos grupės pacientams (p<0,005).

Tai, kad po mini-sternotomijos atlikimo gaunamas geresnis kosmetinis rezultatas, nekelia jokių abejonių. Apibendrinant galima teigti, kad pacientų pasitenkinimas po mini-sternotomijos operacijos buvo žymiai didesnis ne tik dėl geresnio kosmetinio rezultato, bet ir dėl greitesnio

grįžimo prie kasdienės veiklos. Vertinant operacijų rezultatus praėjus 90 ir 360-imt dienų nuo operacijos atlikimo paaiškėjo, kad mažiau nusiskundimų turi mini-sternotomijos grupės pacientai, tačiau kadangi imtis nebuvo didelė, gautos išvados turi būti tikslinamos, atliekant daugiau tyrimų. Vertinant tolimesnius rezultatus, susijusius su penkerių metų trukmės pacientų išgyvenamumu po abiejų tipų operacijų atlikimo, esminių skirtumų nebuvo pastebėta.

IŠVADOS

1. Aortos vožtuvo protezavimas pasitelkiant ministernotomiją yra tokia pat saugi ir veiksminga chirurginė operacija, kaip ir vidurinė sternotomija.

2. Aortos vožtuvo protezavimui taikant ministernotomiją reikia ilgesnio aortos užspaudimo laiko ir didesnės trukmės dirbtinės kraujotakos, palyginti su vidurinės sternotomijos grupe.

3. Ministernotomijos grupės pacientų dirbtinės plaučių ventiliacijos trukmė buvo statistiškai reikšmingai trumpesnė, išsiskyrusio per drenus kraujo kiekis mažesnis, jiems reikėjo mažiau vaistų koagulopatijai koreguoti bei mažiau adrenalino ir morfino, reanimacijos skyriuje gulėjo trukmė trumpiau ir jiems mažiau reikėjo perpilti eritrocitų masės bei šviežiai šaldytos plazmos.

4. Ankstyvasis pooperacinis laikotarpis pacientams, operuotiems, naudojant mini sternotomijos metodiką, pasižymi statistiškai geresniu kosmetiniu poveikiu, mažesniu skausmu per pirmas 7 dienas po operacijos, ankstyva reabilitacija, mažesniu pooperacinių komplikacijų skaičiumi, trumpesne hospitalizacijos trukme, ir rečiau buvo skiriami Nesteroidiniai vaistai nuo uždegimo.

5. Vėlesnis pooperacinis laikotarpis pacientams, operuotiems, naudojant ministernotomijos metodiką, pasižymi statistiškai didesniu skaičiumi pacientų, neturinčių jokių nusiskundimų metų laikotarpiu po ministernotomijos. Praėjus 30 ir 90 dienų bei 2 ir 3 metams po operacijos, reikšmingų skirtumų tarp grupių nebuvo. Jokių naujų širdies intervencijų šiais laikotarpiais neatlikta. Ministernotomijos grupės pacientų išgyvenamumas sudarė 91,4 %, sternotomijos grupės – 97,1 %, tačiau reikšmingų skirtumų tarp grupių neaptikta.

6. Atlikus koreliacinę analizę nustatyta, kad sternotomijos grupėje gerokai daugiau priešoperacinių rodiklių turi ryšį su operacijos eiga ir pooperacinio laikotarpio ypatumais. Šiems rodikliams priklauso amžius, kraujo krešumas, EuroSCORE, maksimalus ir vidutinis gradientas,

hemoglobino ir kreatinino lygis. Ministernotomijos grupėje mažesnis skaičius veiksnkų turėjo įtakos operacijos rezultatams, o tai netiesiogiai rodo, jog ši prieiga yra tinkamesnė didesnei kategorijai pacientų.

7. Remiantis antsvorio tuinčių homogeniškų pacientų grupių analize nustatyta, kad geresni pooperaciniai šių pacientų rodikliai yra atlikus ministernotomiją. Tai yra:

a. sumažėja ūminio inkstų nepakankamumo išsivystymo dažnis;

b. geresni subjektyvūs pacientų pojūčiai po operacijos;

c. statistiškai daugiau ministernotomijos grupės pacientų neturi nusiskundimų praėjus 90 ir 360 dienų po operacijos;

d. geresnis kosmetinis rezultatas;

e. mažesnis medikamentinės terapijos poreikis hemodinamikai palaikyti ir mažesnis analgetikų vartojimas.

8. Remiantis antsvorio sąsajų su operacijos eigos ir pooperaciniais rezultatais analizės išvadomis nustatyta, kad abiejose grupėse nėra reikšmingos kūno masės indekso koreliacijos nė su vienu iš rodiklių.

PRAKTINĖS REKOMENDACIJOS

1. Jeigu pacientai pasižymi vienodomis klinikinėmis charakteristikomis ir jiems nėra jokių vienos ar kitos prieigos kontraindikacijų, renkantis chirurginės intervencijos metodą prioritetinis turėtų būti ministernotomija.

2. Dėl daugelio ministernotomijos privalumų, palyginti su vidurinės prieigos operacija, šis metodas turėtų būti pripažintas tinkamu pasirinkimu operuojant antsvorio turinčius ar nutukusius pacientus dėl aortos vožtuvo patologijos.

3. Koreliacinių ryšių analizė parodė, kad ministernotomijos grupės pacientų operacijos eiga mažiau priklauso nuo amžiaus. Todėl ji gali būti rekomenduojama ne tik rizikos grupės, pavyzdžiui, vyresnio amžiaus, asmenims, bet ir jaunesnio amžiaus pacientams.