



ANTEROGRADE VS ANTERO-/RETROGRADE DEL NIDO CARDIOPLEGIA IN AORTIC VALVE SURGERY

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SUMMARY – Background: Myocardial protection involves different methods aimed at preventing or reducing ischemia-reperfusion damage to the myocardium during surgery to preserve postoperative heart function.

Methods: This study included 100 adult patients undergoing primary isolated elective surgery for aortic valve stenosis. They were divided into two groups of 50 participants: the experimental group received the del Nido cardioplegic solution antero-retrogradely and the control group received it anterogradely.

Results: The results in the experimental group showed a statistically significant difference in the values of Na⁺, Ca⁺⁺ and K⁺ parameters when comparing values intraoperatively and postoperatively. In the control group, a statistically significant difference ($P < 0.001$) was observed in the values of parameters for Na⁺, K⁺, Ca⁺⁺ and left ventricular ejection fraction (LVEF) intraoperatively and postoperatively. In the control group, intraoperative dobutamine use was 8.5 times higher (95% CI: 2.02-75.85) than postoperative dobutamine use. Also, intraoperative use was 5 times higher compared to the experimental group (95% CI: 2.38-14.16). As for norepinephrine, intraoperative use was 4.5 times higher (95% CI: 1.48-18.28) and 3.8 times higher (95% CI: 1.37-13.02) than postoperative use in the experimental group and the control group, respectively. The incidence of heart rhythm disturbances in the control group was 10 times higher (95% CI: 1.42-433.97) postoperatively than intraoperatively.

Conclusion: This study indicates that the application of the del Nido cardioplegic solution using both methods (antero-retrograde) in patients undergoing isolated aortic valve stenosis surgery offers a higher level of myocardial protection compared to the sole antero-antegrade application of del Nido cardioplegia.

Keywords: *cardioplegia; aortic valve; antero-antegrade; retrograde.*

Introduction

Cardiac muscle damage can be global or local, leading to reversible stiffness or irreversible necrosis, ultimately resulting in ventricular dysfunction – a major cause of postoperative cardiac morbidity and mortality. The primary cause of mortality after cardiac surgery in approximately 90% of patients is subendocardial

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damage of varying degrees to the left ventricular myocardium¹.

The cause of this damage is multifactorial, representing an imbalance between myocardial energy and oxygen supply and demand preoperatively, perioperatively and postoperatively^{2,3}. Clinical manifestations after myocardial damage vary from the inability to wean off the cardiopulmonary bypass (CPB) (due to malignant arrhythmias, severe heart failure, or ischemic contracture — stone heart), to heart failure syndrome with moderate damage requiring mechanical or pharmacological inotropic support during or immediately after surgery, and heart failure at the end of hospitalization or shortly after discharge. In some patients, signs of heart failure develop months or years after surgery due to later myocardial fibrosis^{4,5}.

Adequate perioperative myocardial protection aims to provide the surgeon with optimal time for work and a clear view of the affected heart structures, while simultaneously preserving cardiac function with minimal structural, metabolic or functional damage to the cardiac muscle. This can be achieved by reducing cardiac metabolism while optimizing the relationship of energy supply and demand in the myocardium during and after the initial myocardial ischemia.

In order for the cardioplegic solution to have an adequate effect, it is necessary that it reaches all parts of the heart in sufficient quantity. That is not possible with an anterograde application of cardioplegia in a hypertrophied heart with aortic valve stenosis and severe coronary disease. Retrograde cardioplegia overcomes these limitations. Also, retrograde perfusion improves subendocardial perfusion, which is especially important in a hypertrophied heart. The venous drainage of the heart mainly goes to the right atrium through the coronary sinus, but a smaller part of the cardiac veins is drained via venous-venous shunts, the anterior cardiac vein or the Thebesian veins directly into the ventricles, especially the right half of the heart. A retrograde application of cardioplegia reduces nutritional flow by 30–80%, mainly at the expense of the right ventricle (and to a lesser extent the rear wall of the left ventricle). As a result, there is hypoperfusion of the right heart with the cardioplegic solution and inadequate cardioprotection. On the other hand, anterograde flow is 90% nutritious and ensures a better perfusion and protection of the right ventricle^{6–9}.

The objective of this study was to assess the difference in the cardioprotective effects of an anterograde/retrograde and solely anterograde administration of the del Nido cardioplegic solution in patients undergoing surgery for isolated aortic valve stenosis.

Patients and Methods

This study included 100 adult patients undergoing primary isolated elective surgery for aortic valve stenosis. The patients underwent a thorough medical history review and clinical examination, with an analysis of medical records to determine eligibility for the study.

After selecting patients based on the abovementioned criteria, they were randomly divided into two groups of 50 participants: the experimental group, where patients received the del Nido cardioplegic solution antero-retrogradely (through the aortic root or the coronary artery ostia and in the coronary sinus), and the control group, where the del Nido cardioplegic solution was administered anterogradely (through the aortic root or the coronary artery ostia).

Inclusion criteria for participation in this study were symptomatic aortic valve stenosis, a single administration of cardioplegic solution, aortic clamping time of 40–60 minutes, myocardial ejection fraction > 30%, written consent from the patient and age > 18 years. Exclusion criteria for participation in this study were coronary heart disease, congenital heart defects, inappropriate anatomical variations, pregnancy, REDO procedures (heart reoperations) and pericarditis.

The research had a retro-prospective design. Two methods of administering the del Nido cardioplegic solution were employed: anterograde and antero-retrograde. The study lasted for one year and one month (from December 1, 2022 to December 31, 2022) and was conducted at the Cardiovascular Surgery Clinic of the University Clinical Center Tuzla. There was no differentiation between groups regarding the age and sex of the participants. Echocardiography for all patients was performed by a single cardiologist using the same machine. Extracorporeal circulation was conducted on the Stockert S5 machine.

The operative technique involved a standard protocol of general anesthesia and median sternotomy using extracorporeal circulation under mild systemic

hypothermia conditions (32–34 °C). Myocardial protection was achieved by administering a cold crystalloid del Nido cardioplegic solution (4 °C) in a single dose of 1000 ml. The same perfusionist, a professional responsible for conducting extracorporeal circulation (CPB), prepared the cardioplegic solution for all patients. In the experimental group, we placed one cannula for cardioplegia in the aorta and the other in the coronary sinus through the right atrium and, after clamping the aorta, applied cardioplegia through them. In the control group, we only placed a cannula for cardioplegia in the aorta. We limited the time of aortic clamping to 40–60 minutes in order to be in the ideal time for cardioplegia work. The cardioplegic solution itself was an extracellular solution mixed with autologous blood obtained from the extracorporeal circuit. The crystalloid-to-blood ratio was 4:1. A dose of 20 ml/kg was calculated to achieve optimal myocardial protection for a duration of 90 minutes. Delivery pressure was 100–200 mmHg and delivery flow 200–300 ml/min. Cardioplegia infusion pressure was monitored by the perfusionist on the extracorporeal circulation machine according to the provided protocol. Potassium concentration was >25 mEq/l. The achieved myocardial temperature was <15 °C. The crystalloid solution included Plasma-Lyte as the base solution, and mannitol, magnesium sulfate, bicarbonates, potassium and lidocaine. Some components may have different concentrations and volumes in other European countries.

The composition of the del Nido cardioplegia used in our study was: Plasma-lyte (500 ml), Mannitol (8.5 ml), MgSO₄ 2 g (5.0 ml), NaHCO₃ (6.0 ml), KCl 2 mmol (6.5 ml), Lidocaine, 2% (3.25 ml) and blood (135 ml).

The degree of myocardial protection was assessed by monitoring preoperative, intraoperative and postoperative clinical parameters. Preoperative parameters were echocardiographic parameters [left ventricular ejection fraction (LVEF), abnormalities in regional myocardial motion]. Intraoperative parameters were a spontaneous restoration of cardiac rhythm after aortic clamp release, maximum reduction in mean arterial pressure after cardioplegic solution administration, newly occurring ischemic ECG changes during the reperfusion phase, the need for defibrillation, the need for an intra-aortic balloon pump (IABP), the inability

to wean off extracorporeal circulation, the need for inotropic drugs (dobutamine and norepinephrine), cardiac rhythm disturbance and electrolyte imbalance (Na⁺, K⁺, Ca⁺⁺, Mg⁺⁺) values. Postoperative parameters were echocardiographic parameters (change in LVEF 72 hours after surgery, abnormalities in regional myocardial motion), electrolyte imbalance (Na⁺, K⁺, Ca⁺⁺, Mg⁺⁺), cardiac rhythm disturbance, the need for inotropic drugs (dobutamine and norepinephrine) and mortality.

The statistical significance of the difference in numerical variables was tested using the Mann-Whitney test. The association between the frequency of occurrences and the applied treatment was tested using the χ^2 (chi square) test. When a statistically significant association was determined using the χ^2 test, the Odds ratio was calculated. The processing and graphical presentation of data and statistical hypotheses testing were done using the "R" program for statistical data processing.

Results

A statistically significant difference in the preoperative LVEF parameter was found between the experimental and control group (Table 1). In the experimental group, there was no statistically significant difference in the postoperative and preoperative values of LVEF. In the control group, a statistically significant difference in the value of LVEF was determined postoperatively compared to preoperatively ($P < 0.008$).

Table 1. Pre- and postoperative values of LVEF between the observed groups

Status	LVEF	Experimental group (n)	Control group (n)
Preoperative	>50%	27	41
	<50%	23	9
Postoperative	>50%	28	33
	<50%	22	17
	P-value	>0.05	<0.008*

Note: LVEF- left ventricular ejection fraction; n- number of patients

Additionally, there was a statistically significant difference in intraoperative Ca^{++} values and postoperative Mg^{++} values between the experimental and control group (Table 2).

Table 3 shows a comparison of intra- and postoperative Na^+ , Ca^{++} , K^+ and LVEF parameters for each group individually. In the experimental group, a statistically significant difference in the values of Na^+ , Ca^{++} and K^+ parameters was found when comparing intra- and postoperative values. Comparing the values of the Na^+ , K^+ , Ca^{++} and LVEF parameters revealed a statistically significant difference in the intra- and postoperative values of the parameters in the control group (Table 3).

Table 4 provides the test and *P*-values for the frequency of dobutamine and norepinephrine administration, heart rhythm disturbances and cardiac motion disturbances intra- and postoperatively for each group individually; it also highlights that we identified a statistically significant difference in the intraoperative use of dobutamine between the experimental and control group.

In the experimental group, there was a statistically significant difference in the frequency of norepineph-

rine use, both intra- and postoperatively. In the control group, there was a statistically significant difference in the frequency of dobutamine and norepinephrine use and the frequency of cardiac motion disturbances and heart rhythm disturbances, both intra- and postoperatively. The calculation revealed that intraoperative use of dobutamine therapy was 5 times higher (95% CI: 2.38–14.16) in participants in the control group than in the experimental group. The lower value of the 95% confidence interval (95% CI) indicates that intraoperative use of dobutamine was at least 2.38 times higher in the control group than in the experimental group.

Graph 1 depicts norepinephrine use in the experimental group; it was administered to 28 (56%) participants intraoperatively, while this number decreased to 14 (28%) postoperatively. Ten participants who received norepinephrine intraoperatively also received it postoperatively, while 18 participants were not treated with norepinephrine at all. None of the 18 participants treated with norepinephrine intraoperatively required this treatment postoperatively, while four participants who were not treated intraoperatively required the treatment postoperatively.

Table 2. Electrolyte parameters intraoperatively and postoperatively between the observed groups

Electrolyte	Status	Experimental group (Mdn)	Control group (Mdn)	<i>P</i> -value
Na^+	IO	134	134	0.605
	PO	139	140	0.22
K^+	IO	4.65	4.55	0.494
	PO	3.90	3.80	0.166
Ca^{++}	IO	2.10	2.04	0.045*
	PO	2.15	2.16	0.97
Mg^{++}	PO	0.88	0.78	0.004*

Note: Na^+ – Sodium; Ca^{++} – Calcium; K^+ – Potassium; Mg^{++} – Magnesium; IO – intraoperative; PO – postoperative; Mdn – Median

Table 3. Parameters of Na^+ , K^+ , Ca^{++} and LVEF intra- and postoperatively, for each group individually.

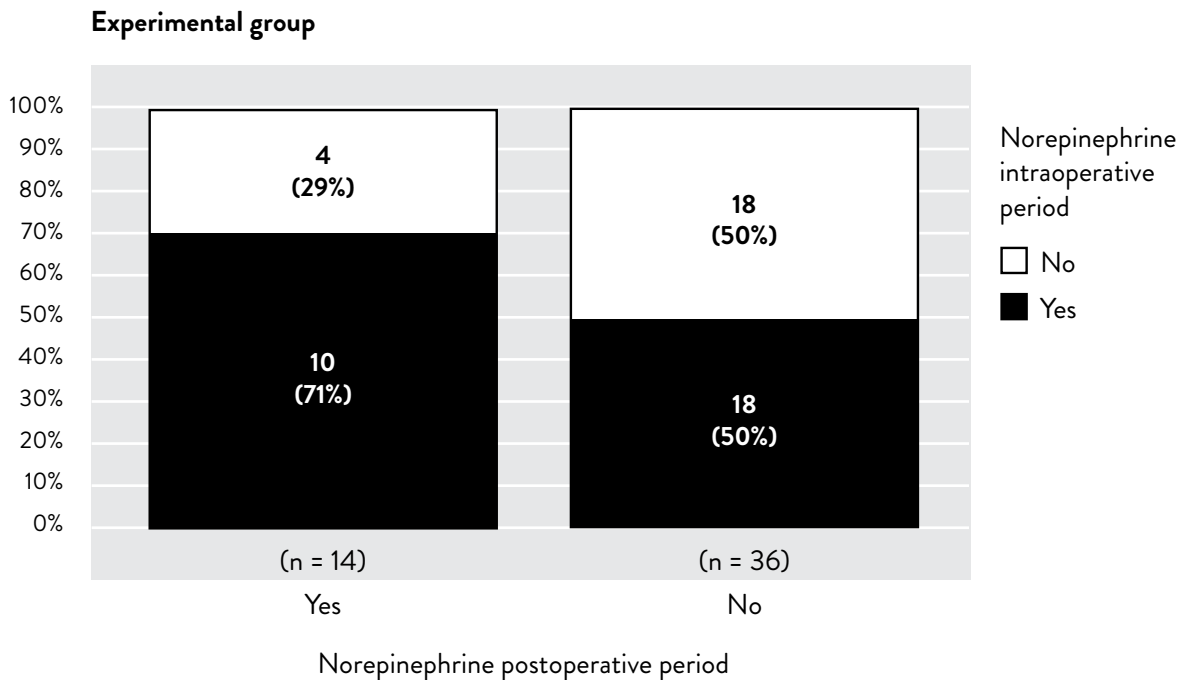
Group		Na^+	Ca^{++}	K^+	LVEF
Experimental group	Mann-Whitney U	23	277	1250	54
	<i>P</i> -value	<0.001*	<0.001*	<0.001*	0.949
Control group	Mann-Whitney U	1174	1203	26	190
	<i>P</i> -value	<0.001*	<0.001*	<0.001*	<0.001*

Note: Na^+ – Sodium; Ca^{++} – Calcium; K^+ – Potassium; LVEF – left ventricular ejection fraction

Table 4. Frequency of dobutamine and norepinephrine use, heart rhythm disturbances and cardiac motion disturbances intra- and postoperatively for each group individually and between the observed groups.

Group		D	NE	Disturbance of heart rhythm	Heart motility disorder
Experimental group	IO (n)	19	28	16	14
	PO (n)	20	14	17	14
	P-value	1.000	0.006*	0.550	1.000
Control group	IO (n)	39	33	10	0
	PO (n)	24	19	19	12
	P-value	0.001*	0.008*	0.016* χ	0.041*
Ex/C (IO)	P-value	<0.001*	0.416		

Note: D – dobutamine, NE – norepinephrine; IO – intraoperative; PO – postoperative; Ex – Experimental group; C – control group

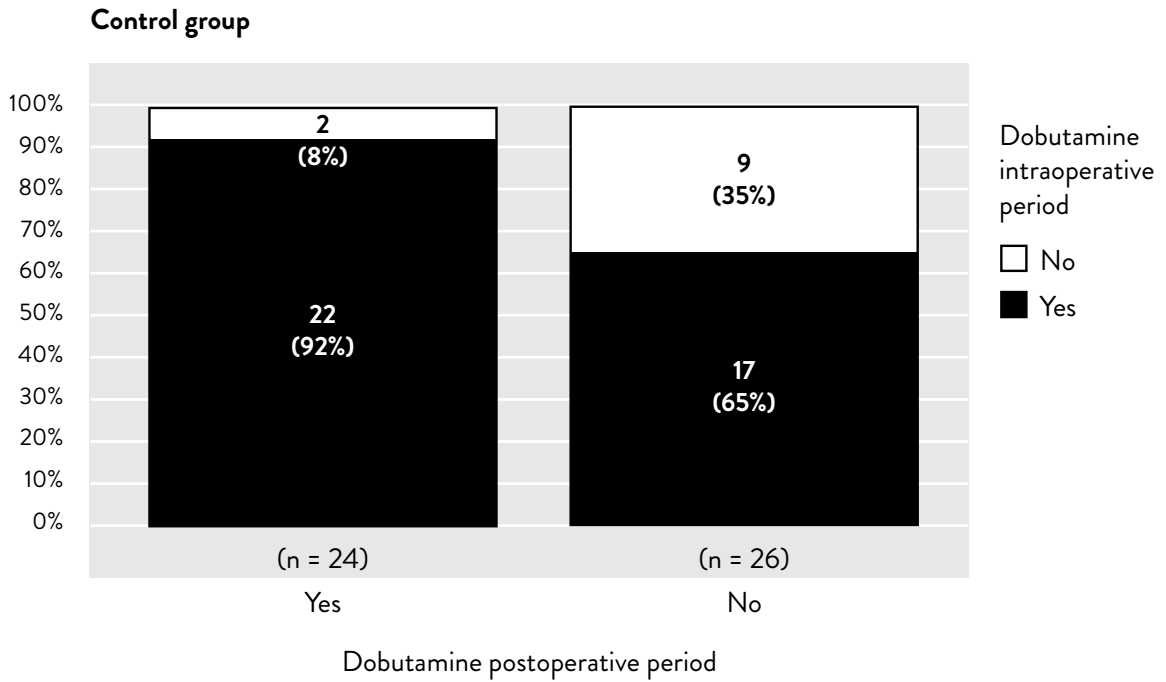


Graph 1. Distribution of the frequency of norepinephrine use intra- and postoperatively in the experimental group.

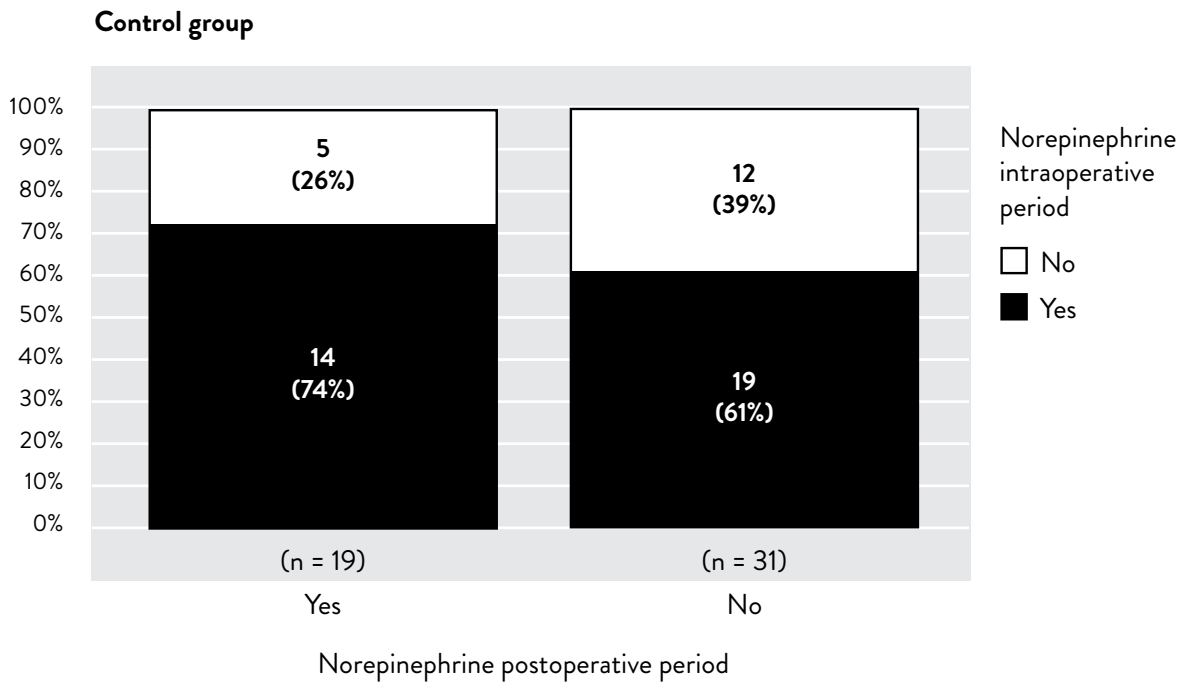
In the experimental group, norepinephrine use was 4.5 times higher (95% CI: 1.48-18.28) intraoperatively than postoperatively.

Graph 2 depicts dobutamine use in the control group; dobutamine was administered to 39 (78%) participants intraoperatively, while this number decreased to 24 (48%) postoperatively. Twenty-two patients treated with dobutamine intraoperatively were also

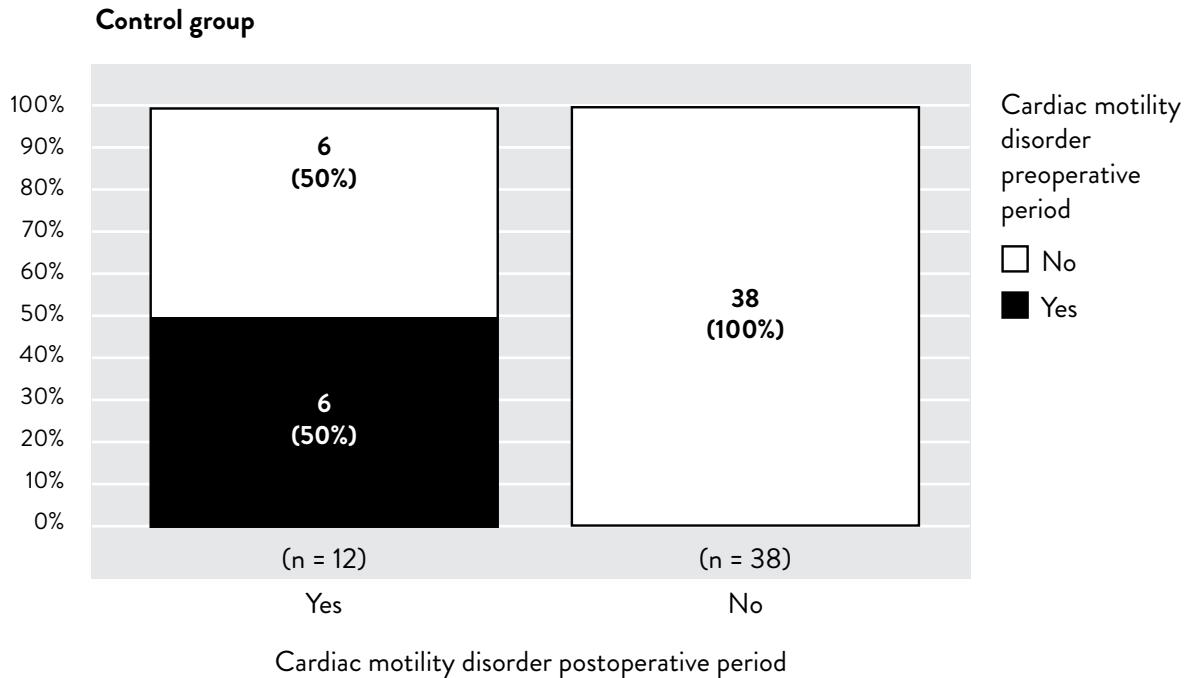
treated postoperatively, while nine participants were not treated with dobutamine at all. A total of 17 participants treated with dobutamine intraoperatively did not require this treatment postoperatively, while two patients who were not treated intraoperatively required it postoperatively. In the control group, dobutamine use was 8.5 times higher (95% CI: 2.02-75.85) intraoperatively than postoperatively.



Graph 2. Distribution of the frequency of dobutamine use intra- and postoperatively in the control group.



Graph 3. Distribution of the frequency of norepinephrine use intra- and postoperatively in the control group.



Graph 4. Distribution of the frequency of cardiac motion disturbances pre- and postoperatively in the control group.

Graph 3 illustrates norepinephrine use in the control group; it was administered to 33 (66%) participants intraoperatively, while this number decreased to 19 (38%) postoperatively. Fourteen participants treated with norepinephrine intraoperatively were also treated postoperatively, while 12 participants were not treated with norepinephrine at all. Nineteen participants treated with norepinephrine intraoperatively did not require this treatment postoperatively, while five participants who were not treated intraoperatively required it postoperatively.

In the control group, norepinephrine use was 3.8 times higher (95% CI: 1.37–13.02) intraoperatively than postoperatively.

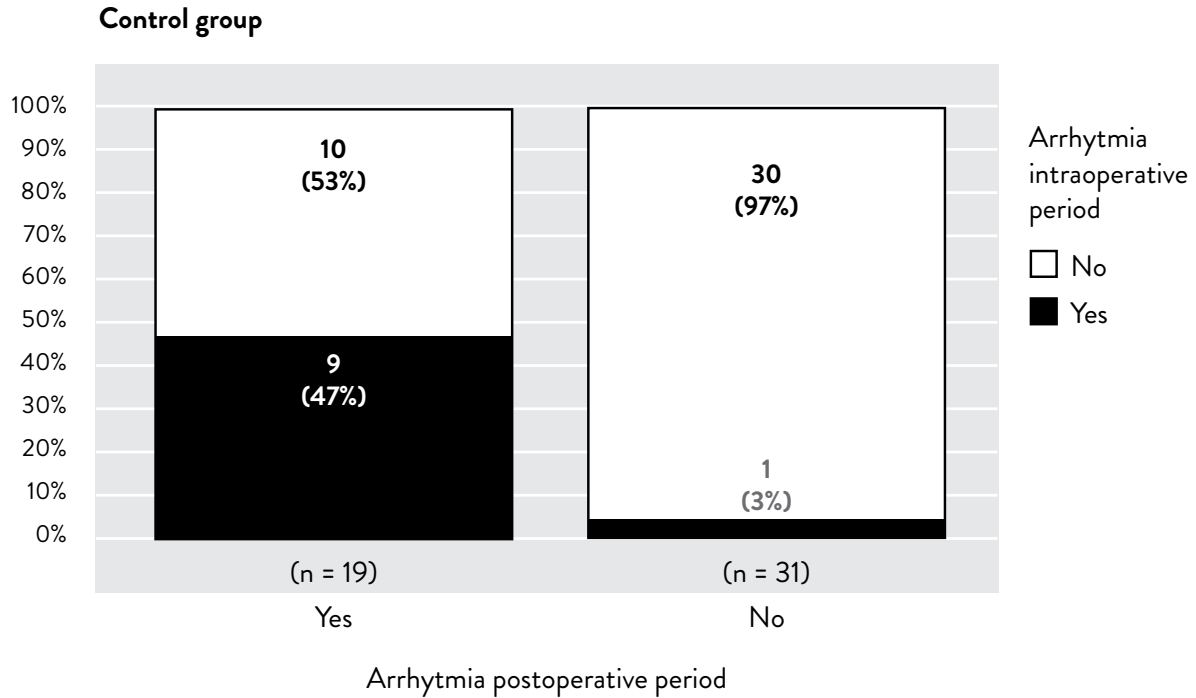
Graph 4 shows the incidence of cardiac motion disturbances in the control group; they were observed in 6 (12%) participants before surgery, while 44 participants did not have cardiac motion disturbances before surgery. Of the six participants who had cardiac motion disturbances before surgery, the same problem persisted after surgery. However, six participants who did not have this problem before surgery developed cardiac motion disturbances postoperatively; therefore

thirty-eight participants did not have any cardiac motion disturbances intra- or postoperatively. In this case, we cannot calculate the odds ratio since none of the participants had cardiac motion disturbances preoperatively but not postoperatively.

Graph 5 shows that heart rhythm disturbances were observed intraoperatively in 10 (20%) participants, while postoperatively this number increased to 19 (38%) in the control group. Nine participants who had heart rhythm disturbances intraoperatively had the same problem postoperatively. Thirty participants did not have heart rhythm disturbances neither during nor after surgery. One patient had heart rhythm disturbances intraoperatively, but did not have this problem postoperatively. On the other hand, 10 participants did not have heart rhythm disturbances intraoperatively, but this problem was observed postoperatively.

We discovered that the chance of experiencing new-onset heart rhythm disturbances was 10 times higher (95% CI: 1.42–433.97) after surgery than during surgery in the control group.

The results of our study have shown a statistically significant difference in parameters for preoperative



Graph 5. Distribution of the frequency of heart rhythm disturbances intraoperatively and postoperatively in the control group.

EFLV, intraoperative Ca^{++} and postoperative Mg^{++} between the experimental and control groups.

In the experimental group, a statistically significant difference in the values of Na^+ , Ca^{++} and K^+ parameters was found when comparing values during and after surgery. In the control group, a statistically significant difference ($P < 0.001$) in the values of parameters for Na^+ , K^+ , Ca^{++} and EFLV during and after surgery was observed.

Dobutamine use was 8.5 times higher (95% CI: 2.02–75.85) during surgery than after surgery in the control group, and intraoperative dobutamine use was 5 times higher compared to the experimental group (95% CI: 2.38–14.16).

The use of norepinephrine was 4.5 times higher (95% CI: 1.48–18.28) and 3.8 times higher (95% CI: 1.37–13.02) during surgery than after surgery in the experimental and the control group, respectively.

The frequency of heart rhythm disturbances in the control group was 10.0 times higher (95% CI: 1.42–433.97) after surgery than during surgery.

Discussion

Cardiac surgical procedures are always accompanied by a certain degree of myocardial injury. The causes are multiple and cumulative, with ischemia and reperfusion or inadequate myocardial protection being the leading factors in intraoperative myocardial damage. Strategies for myocardial protection during surgical procedures aim to reduce ischemia-reperfusion injury to the myocardium, which can lead to myocardial infarction, arrhythmias, ventricular dysfunction and heart failure syndrome. Atrial fibrillation, the need for inotropic support, acute kidney injury, prolonged stay in the intensive care unit and death are the most common consequences of heart failure syndrome.

Extracorporeal circulation, along with hypothermia and cardioplegic cardiac arrest, has been a milestone in cardiac surgery and is considered the primary technique — the gold standard — for intraoperative myocardial protection during open-heart surgeries. Cardioplegia, as a method of myocardial protection, has been in use for almost half a century. Various

cardioplegic solutions are widely used today to arrest the heart during coronary artery bypass grafting (CABG) and other cardiac surgeries. In order to minimize interruptions during surgery for periodic dosing of cardioplegia and to facilitate less invasive cardiac procedures, single-use solutions, including Bretschneider and del Nido solutions, have been introduced. However, the superiority of one type of cardioplegia or one method of administering cardioplegic solution has still not been demonstrated. The ideal composition and method of administering cardioplegic solutions remain open.

A significant number of surgeons use retrograde cardioplegia, not only as a supplement to anterograde cardioplegia, but also as an alternative in specific complex surgeries. Many cardiac surgeons advocate for the standard use of retrograde cardioplegia in coronary surgery, while others do not propose it as a standard practice. The disagreement is a result of varying results among protocols studying the effect of anterograde and retrograde perfusion. Fundamental variations in design, materials and methods have made it impossible to compare results. Most published protocols provide only a rough estimate of microcirculatory perfusion¹⁰.

In their study on myocardial protection using the del Nido cardioplegic solution in reoperations of the aortic valve in adults, Robert *et al.*¹¹ found that the del Nido cardioplegic solution provides comparable postoperative outcomes to blood cardioplegia. Additionally, the use of del Nido cardioplegia requires a smaller total and retrograde volume of cardioplegia to achieve adequate myocardial protection. Their study included several patients who received continuous retrograde cardioplegia without differences in postoperative outcomes.

Sanetra *et al.*¹² demonstrated in their study that, for patients with impaired contractility undergoing valvular and complex procedures, the use of del Nido cardioplegia as an alternative to cold blood cardioplegia is associated with lower troponin release and improved preservation of the ejection fraction. Their results show significantly more frequent rhythm disturbances in patients who received cold-blood cardioplegia compared to those who received del Nido cardioplegia. Our study also confirmed a lower probability of rhythm disturbances when cardioplegia was given in an anterograde-retrograde manner.

In their research on minimally invasive AVR surgery, Ziazadeh *et al.*¹³ found that del Nido cardioplegia provides myocardial protection and clinical outcomes equivalent to blood cardioplegia. Moreover, it simplified the cardioprotective regimen and reduced aortic clamping time. Del Nido cardioplegia was associated with lower glucose levels in CPB and demonstrated the feasibility of a single-dose application. In contrast to our study, there was no change in LVEF postoperatively in patients who received blood cardioplegia or del Nido cardioplegia, even though blood cardioplegia was given both anterogradely and retrogradely.

Tian *et al.*¹⁴ found that retrograde cardioplegia provides significantly lower capillary flow than anterograde cardioplegia. Its microvascular perfusion varies significantly between different small areas of the heart, resulting in lower efficiency in maintaining a normal myocardial energy metabolism.

Maximum microvascular distribution of cardioplegia is crucial for optimal myocardial protection. Gates *et al.*¹⁵ found that 27–32% of total microvascular capillary flow is attributed to retrograde cardioplegia. Despite being administered under lower pressure, retrograde cardioplegia significantly contributes to overall microvascular distribution and perfusion. The application of only anterograde cardioplegia does not perfuse all myocardial capillaries. Therefore, it can be concluded that the combined use of anterograde and retrograde cardioplegia provides a higher degree of myocardial protection, which we also attempted to explain in our study.

Ascione *et al.*⁶ demonstrated that hot shot retrograde cardioplegia does not provide any additional benefit to anterograde cold cardioplegia in preventing myocardial injury in patients with left ventricular hypertrophy during aortic valve replacement. However, it reduces ischemic stress in the right ventricle. There was no difference in clinical outcomes between the investigated groups. Myocardial reperfusion injury was assessed by measuring ATP and lactate levels in the myocardium using high-performance liquid chromatography and enzymatic techniques.

Although surgeons rely on retrograde cardioplegia for myocardial protection as it ensures adequate perfusion of the left ventricle, it does not provide sufficient perfusion to the right ventricle, as clinically observed by Allen *et al.*¹⁷. They investigated the retrograde

delivery of cardioplegic solution using contrast transesophageal echocardiography, directly assessing myocardial perfusion. Their results showed nearly four times greater perfusion in the free wall of the left ventricle and septum than in the free wall of the right ventricle. In patients with aortic cross-clamping, right ostial drainage was less than 5 ml/min, while left ostial drainage was around 80 ml/min during retrograde cardioplegia, leading to the conclusion that surgeons should not rely solely on retrograde cardioplegia to protect the right ventricle myocardium.

Similar results were obtained by Crooke *et al.*¹⁸ in their study on animal models, examining the effect of modifying the conditions of retrograde cardioplegia application.

Conclusion

The conclusion of this study indicates that the del Nido cardioplegic solution provides a high level of myocardial protection and safety during cardiac surgical treatment of aortic valve stenosis in routine practice. However, its application using both anterograde and retrograde methods in patients undergoing isolated aortic valve stenosis surgery offers a higher level of myocardial protection compared to the sole anterograde application of del Nido cardioplegia.

Clinical indicators of myocardial damage individually and cumulatively show a trend of lower frequency in the experimental group compared to the control group. This is supported by a significantly lower probability of using inotropic drugs, the occurrence of cardiac rhythm disturbances and electrolyte imbalances, and a smaller decrease in EFLV in the experimental group compared to the control group.

Based on previous research on retrograde cardioplegia and the results obtained in our study, we believe that using retrograde cardioplegia as an adjunct to anterograde cardioplegia is preferable in cardiac surgery.

The limitations of this study include its sample size (100) and the fact that it was conducted in a single institution. Additionally, we were unable to perform myocardial tissue analysis to assess acute tissue injury. Further long-term cardiac data are necessary to confirm our current findings.

Due to the limitations of our study and considering the limited existing research on this topic for comparison, further exploration in this field is warranted.

Conflict of Interest

The authors declare no conflict of interest.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University Clinical Center Tuzla (Date: 27.07.2023.; No: 02-09/2-51/23)

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Sažetak

USPOREDBA ANTEROGRADNE I ANTERO-RETROGRADNE PRIMJENE DEL NIDO KARDIOPLEGIJSKE OTOPINE

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Pozadina: Zaštita miokarda obuhvaća različite metode usmjerene na sprečavanje ili smanjenje oštećenja miokarda uzrokovanog ishemijom i reperfuzijom tijekom operacije, s ciljem očuvanja postoperativne funkcije srca.

Metode: Ovo istraživanje uključuje 100 odraslih pacijenata koji su podvrgnuti primarnoj, izoliranoj i elektivnoj operaciji zbog stenoze aortnog zaliska. Sudionici su bili podijeljeni u dvije skupine po 50 ispitanika: eksperimentalna skupina primala je del Nido kardioplegijsku otopinu antero-retrogradno, dok je kontrolna skupina primala otopinu samo anterogradno.

Rezultati: U eksperimentalnoj skupini utvrđena je statistički značajna razlika u vrijednostima parametara natrija, kalcija i kalija pri usporedbi intraoperativnih i postoperativnih vrijednosti. U kontrolnoj skupini uočena je statistički značajna razlika ($P < 0,001$) u vrijednostima parametara Na^+ , K^+ , Ca^{2+} i ejekcijske frakcije lijeve klijetke intraoperativno i postoperativno. Vjerojatnost primjene dobutamina u kontrolnoj skupini bila je 8,5 puta veća (95% CI: 2,02–75,85) intraoperativno nego postoperativno, dok je intraoperativno bila 5 puta veća u usporedbi s eksperimentalnom skupinom (95% CI: 2,38–14,16). Vjerojatnost primjene noradrenalina u eksperimentalnoj skupini bila je 4,5 puta veća (95% CI: 1,48–18,28), dok je u kontrolnoj skupini bila 3,8 puta veća (95% CI: 1,37–13,02) intraoperativno nego postoperativno. Učestalost poremećaja srčanog ritma u kontrolnoj skupini bila je 10 puta veća (95% CI: 1,42–433,97) postoperativno.

Zaključak: Ovo istraživanje pokazuje da primjena del Nido kardioplegijske otopine kombiniranom (antero-retrogradnom) metodom kod pacijenata podvrgnutih izoliranoj operaciji stenoze aortnog zaliska pruža višu razinu zaštite miokarda u usporedbi s isključivo anterogradnom primjenom del Nido kardioplegije.

Ključne riječi: *kardioplegija; aortna valvula; anterogradno; retrogradno*