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Original Article

Cold Modified Del Nido Cardioplegia in Adults Undergoing Elective Cardiac Coronary Surgery

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Abstract

Introduction: The cardioplegic solution of Kirklin (Kn) is frequently used in adult cardiosurgical patients. It requires reinfusion at short intervals, which causes further difficulty during surgery and the quality of myocardial protection is often called into question.

Aim: To demonstrate whether the modified cardioplegia of del Nido (MDN) with a longer period of cardiac arrest provides sufficiently effective and reliable myocardial protection when compared to the classic cardioplegia of Kirklin we use in our institution.

Materials and methods: This ambispective clinical-epidemiological study was conducted in the Department of Heart Surgery at St Anna University Hospital in Sofia between January 2017 and September 2021. Using a random number generator, a hundred and twenty patients were selected and divided into two cohorts of 60 patients each. After further data processing, an additional five patients dropped out of the Kirklin group due to a 'beating heart' operative technique. As a result, the groups were divided as follows: 1) intermittent cardioplegia Kirklin (Kn, n=55) used in patients between January 2017 and June 2019, and 2) modified del Nido cardioplegia (MDN, n=60) used from June 2019 to September 2021.

Results: In this study, we present our experience with MDN cardioplegia in patients undergoing isolated CABG and compare it with a group of patients who received Kn cardioplegia. The difference in cross-clamp and CPB times is due to the individual qualities and experience of surgeons. When using MDN, the longer intraoperative times not only showed no deterioration in postoperative results, did not increase the need of using an additional dose of cardioplegia, but also did not materialize in a statistically significant difference. The MDN cardioplegia showed significantly less usage of inotropic support ($p<0.001$) and IABP ($p=0.029$). Creatinine phosphokinase MB fraction when patients are admitted to intensive care was significantly less in the Kirklin group ($p=0.045$).

Conclusions: Results suggest that the routine use of modified cardioplegic protection of del Nido in adult patients may be safe, leads to comparable clinical outcomes and could accelerate the surgical process. The reduced incidence in intra- and postoperative complications like DC shocks, arrhythmia, myocardial infarction, multiorgan failure and in-hospital mortality should be further studied, as it may imply superiority of myocardial protection with the modified solution.

Keywords

cardiac surgery, cardioprotection, cardioplegia del Nido, modified del Nido cardioplegia

INTRODUCTION

Intraoperative myocardial protection is central to the evolution of cardiosurgery. Numerous studies assess the effectiveness of cardioplegic solutions, but the ultimate cardioprotective strategy and the search for the perfect cardioplegic solution is still on the agenda. In the early 1990s, professor Pedro del Nido and his team from the University of Pittsburgh developed a cardioplegic solution to address the specific needs of immature myocardium often found during neonatal and children's cardiac surgery. The formula, which we now call del Nido cardioplegia (DN), causes the heart to stop due to muscle depolarization. It is essentially a more diluted solution (1:4, blood:crystalloid) compared to traditional blood cardioplegia solution (4:1). Other characteristics of del Nido solution are the reduced Ca^{2+} content and the addition of a depolarizing agent, lidocaine.[1]

Kirklin's solution is a well-studied crystalloid cardioplegia, administered repeatedly at short intervals during surgery. An increase in myocardial acidosis between cardioplegic doses has been observed adversely affecting the postoperative outcome. It would be useful if the interval between doses can be increased, thereby reducing their total number during surgery. The potential advantage of DN is the fact that it provides a longer period of arrest before a subsequent dose is needed.[2] Numerous studies share their clinical experience of using DN cardioplegia in adults with good results either with a single dose or with longer intervals between doses.[3-6]

When using a blood vehiculum for classical del Nido cardioplegia, the need for additional inventory arises, and this in turn complicates the operative intervention itself. In our clinic, in order to simplify surgical interventions, we have developed a modified cardioplegic solution based on the electrolyte composition of del Nido, while removing the blood component and replacing it with additional sodium hydrogen carbonate ($NaHCO_3$). The routine use of our modified del Nido cardioplegia has proven its reliability and effectiveness. The concept is built on previous modifications of the solution in which Ringer's solution is used as the main solvent instead of the traditionally used Plasma-Lyte solution.[7,8] In our opinion, it is not the blood component that underpins the proven good results in DN plegia, but the reduced concentration of Ca^{2+} in the Plasma-Lyte solution.

AIM

To demonstrate whether the modified cardioplegia of del Nido (DN) with a longer period of cardiac arrest provides sufficiently effective and reliable myocardial protection when compared to the classic cardioplegia of Kirklin we use in our institution.

MATERIALS AND METHODS

Patient population

This ambispective clinical-epidemiological study was conducted in the Department of Heart Surgery at St Anna University Hospital in Sofia between January 2017 and September 2021. Using a random number generator, a hundred and twenty patients were selected and divided into two cohorts of 60 patients each. After further data processing, an additional five patients dropped out of the Kirklin group due to a 'beating heart' operative technique. As a result, the groups were divided as follows: 1) intermittent cardioplegia Kirklin (Kn, n=55) used in patients between January 2017 and June 2019, and 2) modified del Nido cardioplegia (MDN, n=60) used from June 2019 to September 2021.

Inclusion and exclusion criteria

Inclusion criteria

All patients undergoing surgical revascularization due to ischemic heart disease.

Exclusion criteria

1. Patients undergoing complex surgery intervention with a complication of myocardial infarction:
   - Valve prosthetics
   - Plastics of ventricular septal defect (VSD)
   - Aneurysm repair of left ventricle (LV)
2. All patients undergoing off-pump coronary artery bypass (OPCAB) were excluded from the study
3. All patients undergoing 'beating heart' surgery

Application in cardioplegia

All interventions were performed using a standard protocol of general anesthesia in coronary patients, median sternotomy and cardiopulmonary bypass in systemic normothermia. Myocardial protection was achieved by Kn or MDN cardioplegia as follows: in both groups, the heart was arrested by an induction dose (1 L) cold (4°C) cardioplegia using antegrade delivery. A supplemental dose of cardioplegia was administered into the aortic root and/or through the grafts, with Kn being carried out every 30 minutes. A second dose (500 ml) of MRN was provided only when the clamping time exceeded 50 minutes.

Statistical analysis

Data were analyzed with the statistical packages IBM SPSS Statistics 25.0 and MedCalc Version 19.6.3, as well as Excel Office 2021. The accepted significance level where null hypothesis is rejected was $p<0.05$.

The following methods were applied:

1. Descriptive analysis – the frequency distribution of the variables under consideration.

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2. Graphical analysis – for results visualization.
3. Comparing of relative shares.
4. Fisher's exact test, Fisher-Freeman-Halton exact test and χ^2 – checking the hypotheses about the presence of dependence between categorical variables.
5. Non-parametric test of Kolmogorov-Smirnov and Shapiro-Wilk – to check the normality distribution.
6. Student's t-test – for testing hypotheses of difference between means of two independent samples.
7. Non-parametric Mann-Whitney test – for testing hypotheses of difference between two independent samples.
8. Student's *t*-test – for testing hypotheses of difference between means of two dependent samples.
9. Non-parametric Wilcoxon test – for testing hypotheses of difference between two dependent samples.
10. Regression analysis – to test hypotheses for the presence of dependence between quantitative signs and choice of mathematical model.
11. Friedman's non-parametric test – for testing hypotheses of difference between several dependent samples.
12. Multiple linear regression analysis – to test hypotheses for the presence of dependence of one quantitative characteristic on several other characteristics.

RESULTS

Baseline demography

Participants in the study had a mean age of 64.16±9.15 years (range between 40 and 81 years). Of these, 79 (68.7%) were male and 36 (31.3%) female.

The age group with the largest number (31) of men was 60-69 years, followed by the groups of 50-59 and 70-79 years each with 20 participants, and 80-81 years – 1 patient. Among women with the largest number (17) was the age group 60-69 years, followed by 70-79 years with 17, and 40-49 years – 1 patient.

Descriptive statistics

For the purposes of the present study, patients were allocated to two treatment groups:

Classic cardioplegia (Kirklin) – n=55 (47.8%) and Modified cardioplegia (MDN) – n=60 (52.2%).

General characteristic of the groups

It can be seen in **Table 1** that:

- the mean age of the group with classic cardioplegia was 65.47±9.15 years, and of those with modified cardioplegia – 62.95±9.25 years. The difference between them was not statistically significant;
- the average value of the studied cohort according to BMI was 28.95±5.18 kg/m^2 with no significant difference between the two treatment groups;
- the two study groups were statistically equal on the known confounding factors of gender and age, which suggests a correct basis for subsequent comparisons.

Regarding the investigated quantitative preoperative characteristics **(Table 2)**:

- a statistically significant difference between the two treatment groups was found for creatinine (Cr) and creatinine clearance (CrCl) indicators;
- the higher mean creatinine value was observed in the Kirklin group, whilst the higher creatinine clearance – in the modified group;
- the difference between the two groups was not statistically significant for the rest of the indicators – Euroscore, hemoglobin, erythrocytes, creatinine phosphokinase (CPK), creatinine phosphokinase MB fraction (MB), ejection fraction (LVEF), and hypertrophy of the left ventricle (HLV).

The comparative analysis of the therapeutic groups based on the investigated preoperative characteristics found that **(Table 3)**:

- a significant difference was observed only in the indicator preoperative atrial fibrillation (AF);
- in the group with classic cardioplegia, the percentage of those with preoperative atrial fibrillation (AF) was significantly higher;
- for the rest of the indicators included in the table – diabetes mellitus (DM), myocardial infarction, stroke, balloon dilatation/stent, chronic kidney disease (CKD), mitral insufficiency, pulmonary hypertension and presence of stenosis of the common trunk of the left coronary artery SCTLCA, the differ-

Table 1. Comparative analysis of study groups by age, BMI and gender

Index	Total		Kirklin		MDN		*P*
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
Age (years)	64.16	9.15	65.47	8.93	62.95	9.25	0.140
BMI (kg/m^2)	28.95	5.18	28.17	4.98	29.67	5.29	0.121
	n	%	n	%	n	%	
Gender							0.548
Men	79	68.7	36	65.5	43	71.7	
Women	36	31.3	19	34.5	17	28.3	

Table 2. Comparative analysis of treatment groups by exploratory quantitative preoperative characteristics

Index	Kirklin			MDN			*P*
	n	$\bar{X}$	SD	n	$\bar{X}$	SD	
Euroscore (%)	51	4.57	3.85	60	5.16	4.68	0.929
Hemoglobin (g/l)	55	137.93	16.18	60	137.73	18.47	0.953
Erythrocytes (g/l)	55	4.63	0.61	60	4.69	0.56	0.569
Creatinine (μmol/1)	51	108.78	32.21	57	94.81	22.57	0.011
CrCJ (ml/min)	54	67.26	28.41	60	83.67	35.02	0.007
CPK (U/l)	51	135.22	104.78	58	131.87	79.84	0.540
MB (U/l)	51	20.02	13.21	57	19.77	12.27	0.626
LVEF (%)	55	50.33	8.68	60	53.33	9.31	0.050
HLV (mm)	55	9.62	6.04	60	9.32	6.19	0.735

Table 3. Comparative analysis of the therapeutic groups according to the studied categorical preoperative characteristics

Index	Kirklin		MDN		*P*
	n	%	n	%	
DM	27	49.1	34	56.7	0.458
Acute myocardial infarction	9	16.4	6	10.0	
Myocardial infarction	19	34.5	15	25.0	
Stroke	7	12.7	3	5.0	0.190
Preoperative AF	9	**16.4**	2	3.3	**0.025**
Balloon dilatation/stent	12	21.8	11	18.3	0.650
CKD	8	14.5	5	8.3	0.381
Mitral insufficiency	26	47.3	24	40.0	0.457
Pulmonary hypertension	7	12.7	4	6.7	0.348
SCTLCA	23	41.8	19	31.7	0.333

ence between the two groups failed to reach statistical significance.

Intra- and postoperative variables and outcomes

The comparative analysis of the therapeutic groups according to the investigated intra- and postoperative characteristics found that **(Table 4)**:

- a significant difference was observed in the need for inotropic support and intra-aortic balloon pump (IABP) usage – in Kirklin cardioplegia, the inotropic support in moderate and high doses and IABP were significantly more used compared to the modified one;
- the need to use an additional dose of cardioplegia occurred in 60% of patients with classical cardioplegia and in 48.3% with the modified one – but the difference in relative shares was not statistically significant;
- for the rest of the indicators included in the table: DC shocks, new-onset atrial fibrillation (NAF), new-onset myocardial infarction (NMI), and mortality, we can see better performance in MDN group, but the results were statistically non-significant.

Regarding the studied quantitative intra- and postoperative characteristics **(Table 5)**:

- a statistically significant difference between the two treatment groups was established only in the case of creatinine phosphokinase MB fraction when patients were admitted to intensive care (MB0) – the higher average value was in the modified cardioplegia group;
- a significant difference was observed in the cross clamp time (CCT) – in MDN, the time of cross clamp was significantly more compared to Kirklin group.
- for the rest of the indicators included in the table – initial creatinine phosphokinase (CPK0), creatinine phosphokinase – 24 h after ICU admission (CPK24), creatinine phosphokinase MB fraction – 24 h after ICU admission (MB24), postoperative creatinine clearance (CrCl post), postoperative creatinine (Cr. Post), extracorporeal circulation (CPB), number of distal anastomoses (NDA), intensive care unit (ICU) stay, and hospital stay, the difference between the two groups was statistically non-significant.

Table 4. Comparative analysis of the therapeutic groups according to the investigated categorical intra- and postoperative characteristics

Index	Kirklin		MDN		*p*
	n	%	n	%	
DC shocks	9	16.4	5	8.3	0.256
Additional cardioplegia	33	60.0	29	48.3	0.262
Inotropic support					<0.001
Without	9	16.4	31	51.7	
Medium dosage *	30	54.5	22	36.7	
High dosage **	16	29.1	7	11.7	
IABP usage	12	21.8	4	6.7	**0.029**
NAF	3	5.5	1	1.7	0.348
NMI	4	7.3	2	3.3	0.424
Mortality	5	9.1	2	3.3	0.257

* for a medium dose, we consider inotropic support up to 4 μg/kg/min; ** for a high dose, we consider inotropic support above 4 μg/kg/min

Table 5. Comparative analysis of the therapeutic groups according to the investigated quantitative intra- and postoperative characteristics

Index	Kirklin			MDN			*P*
	n	$\bar{X}$	SD	n	$\bar{X}$	SD	
CPKO (U/l)	52	579.04	296.64	57	654.98	284.42	0.089
MBQ (U/l)	52	62.75	32.06	58	67.64	16.40	0.045
CPK24 (U/l)	52	1040.31	701.14	58	1033.40	727.08	0.808
MB24 (U/l)	51	59.39	53.51	58	63.45	45.41	0.251
CrCI post (ml/min)	55	63.10	24.03	60	72.45	30.86	0.074
Cr. post (μmol/1)	55	133.95	123.76	60	117.88	41.81	0.769
CCT (min)	55	47.76	11.60	60	59.75	13.13	<0.001
CPB (min)	55	101.56	45.49	58	101.95	25.29	0.073
NDA (n)	55	2.82	0.70	60	2.73	0.61	0.639
ICU stay (days)	52	3.75	1.79	59	3.64	1.88	0.726
Hospital stay (days)	52	11.46	3.64	59	11.61	4.25	0.169

Determining the connection between MB24 and preoperative MB, MB on ICU admission and cross clamp time

Kirklin

After elimination of extreme values, a multiple linear regression analysis (backward procedure) was conducted showing that there was a significant dependency (R^2=0.303, p=0.002) of MB24 on the studied predictive factors, which in step 1 is described by a regression equation with the following parameters:

$$MB24 = -15.782 - 0.183\ MB + 0.862\ MB0 + 0.353\ CCT$$

where MB24 is the MB fraction at 24 hours after ICU admission, MB is the preoperative MB fraction, MB0 is the MB fraction after ICU admission, and CCT – cross clamping time.

From the standardized coefficients β **(Table 6)** it can be seen that MB0 has the greatest influence on MB24, followed by CCT and MB.

- A 1 U/L increase in MB results in a mean decrease in MB24 of about 0.183 U/L;
- A 1 U/L increase in MB0 leads to a mean increase in MB24 by about 0.862 U/L;
- A 1-minute increase in CCT leads to an average increase in MB24 with about 0.353 U/L.

The coefficient of determination (R^2) value of 0.303 means that according to the research model the three indicators determine about 30% of the variations of MB24. The moderate strength of the pattern is also observed in the scatter plot between the actual and predicted values of MB24 **(Fig. 1)**.

Table 6. Regression coefficients of the multiple regression model between MB24 and the investigated predictive factors, classic cardioplegia

Stage	Predictors	Unstandardized coefficients		Standardized coefficients	*P*
		β	Std. Error	β	
1	Constant	−15.782	23.231		0.501
	MB	−0.183	0.402	−0.061	0.651
	MB0	0.862	0.224	0.527	<0.001
	CCT	0.353	0.423	0.111	0.409

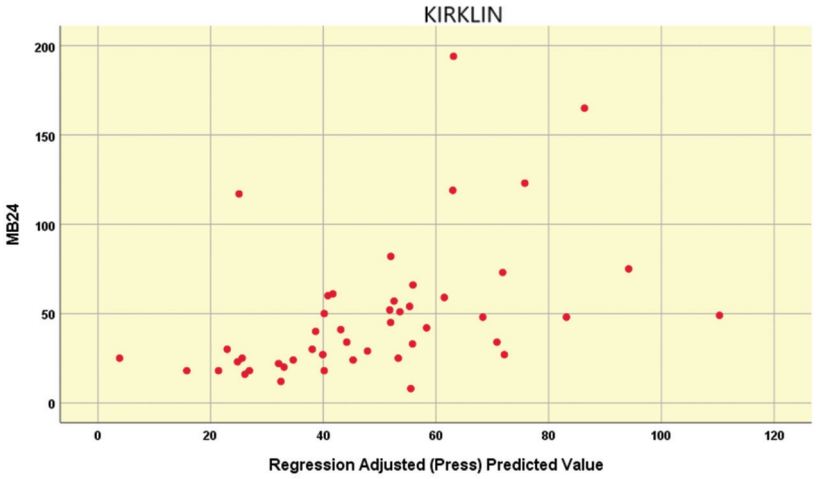

Figure 1. Scatter plot between actual and predicted MB24 values, classic cardioplegia.

Modified del Nido cardioplegia MDN

After eliminating the extreme values of MB24, a multiple linear regression analysis (backward procedure) was conducted and it showed that there was a significant dependency (R^2=0.144, p=0.021) of MB24 on the studied predictive factors, which in step 2 was described by a regression equation with the following parameters (MB is dropped):

MB24 = 1.781 − 0.088 MB0 + 1.002 CCT

where MB24 is the MB fraction at 24 hours after ICU admission, MB0 is the MB fraction after ICU admission, and CCT – cross clamp time.

From the standardized coefficients β **(Table 7)** it can be seen that CCT has the greatest influence on MB24 followed by MB0.

The obtained values of the unstandardized coefficients provide the following information:

- A 1 U/L increase in MB0 results in a mean decrease in MB24 with about 0.088 U/L;
- A 1-minute increase in CCT leads to an average increase in MB24 with about 1.002 U/L.

The coefficient of determination (R^2) value of 0.144 means that according to the research model, the two indicators determine about 14% of the variations of MB24. The small power of the model is also observed in the diagram between the actual and predicted values of MB24 **(Fig. 2)**.

Comparison of pre- and postoperative creatinine clearance

Kirklin

The regression analysis found that of the built-in statistics package in IBM SPSS Statistics 25.0 (eleven models) the relationship between pre- and postoperative creatinine

Table 7. Regression coefficients of the multiple regression model between MB24 and the investigated predictive factors, MDN

Stage	Predictors	Unstandardized coefficients		Standardized coefficients	*P*
		β	Std. Error	β	
2	Constant	1.781	24.385		0.942
	MB0	−0.088	0.281	−0.043	0.754

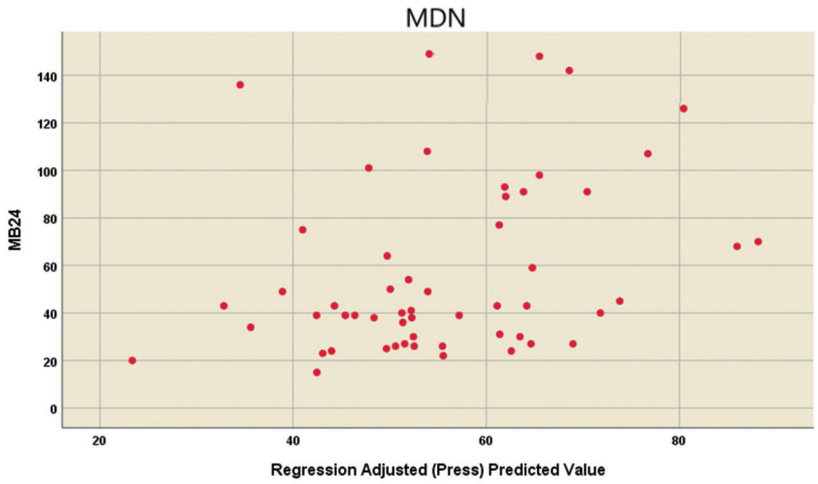

Figure 2. Scatter plot between actual and predicted MB24 values, MDN.

clearance is best described by an exponential equation (R^2=0.834, p<0.001):

CrCl post = 1.759 CrCl 0.850

where CrCl post is the postoperative creatinine clearance and CrCl is the preoperative one. The curve of the equation increases permanently at an angle of about 45°. The value of the coefficient of determination R^2 shows that about 83% of the variations of the investigated indicator after the operation depend on its preoperative values and the rest (about 17%) – on other factors **(Fig. 3)**.

Modified del Nido cardioplegia MDN

The regression analysis found that of the built-in statistics package in IBM SPSS Statistics 25.0. (eleven models), the relationship between pre- and postoperative creatinine clearance is best described by an exponential equation (R^2=0.856, p<0.001):

CrCl post = 1.518 CrCl 0.872

where CrCl post is the postoperative creatinine clearance and CrCl is the preoperative one. The curve of the equation increases permanently at an angle of about 45°. The value of the coefficient of determination R^2 shows that 86% of the variations of the investigated indicator after the operation depend on its preoperative values and the rest (about 14%) – on other factors **(Fig. 4)**.

DISCUSSION

Cardioplegic solutions play a key role in protecting the heart from myocardial damage during cardiosurgical intervention. The DN solution is successfully used in pediatric cardiac surgery[1,4]; however, its use in cardiac surgery in adults was only recently described[3-6]. In this study, we present our experience with MDN cardioplegia in patients

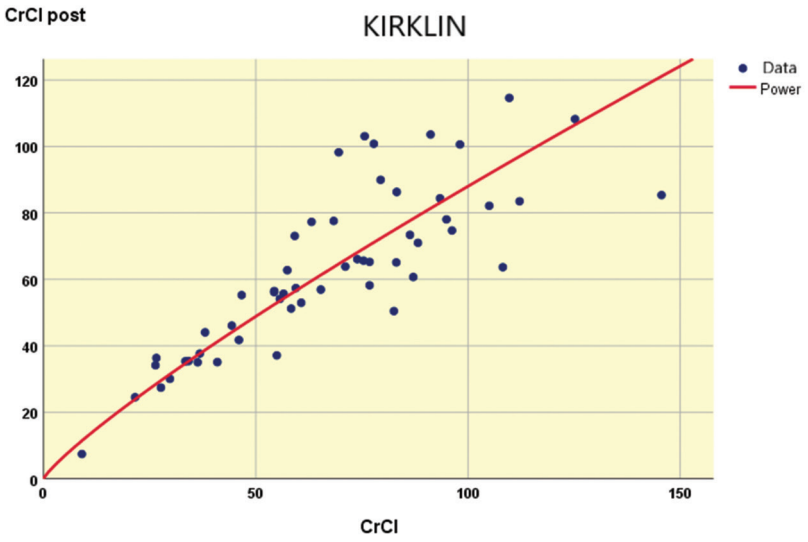

Figure 3. Regression model of the relationship between pre- and postoperative creatinine clearance in Kirklin.

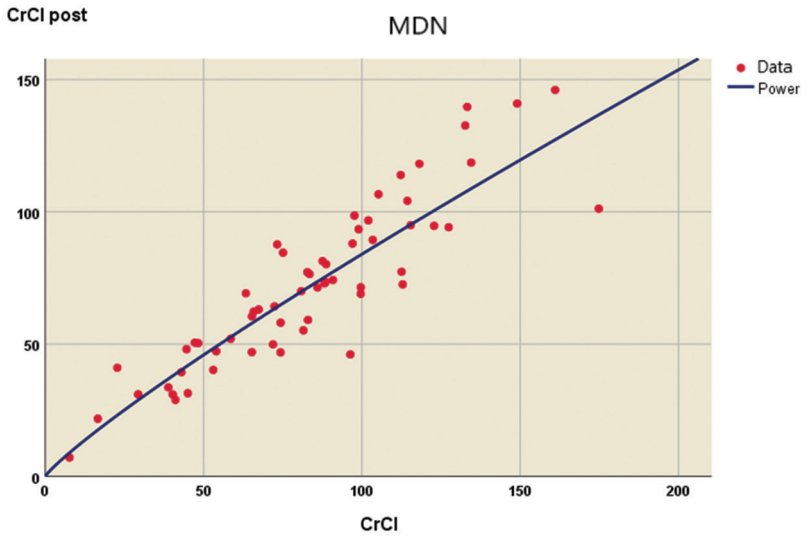

Figure 4. Regression model of the relationship between pre- and postoperative creatinine clearance in MDN.

undergoing isolated CABG and compare it with a group of patients who received Kn cardioplegia. The difference in cross-clamp and CPB times is due to the individual qualities and experience of surgeons. When using MDN, the longer intraoperative times not only showed no deterioration in postoperative results, did not increase the need of using an additional dose of cardioplegia, but this did not materialize in a statistically significant difference. The MDN cardioplegia shows significant less usage of inotropic support (p<0.001) and IABP (p=0.029). Creatinine phosphokinase MB fraction when patients are admitted to intensive care is significantly less in the Kirklin group (p=0.045).

These are the main findings of the present study, and they are consistent with earlier studies using DN in adult patients.[3,6] A single dose of cardioplegia was administered to 51.7% of our patients in the MDN group, with rates reported in studies from different centers ranging from 40% to 84%.[3,5] The lower percentage of 40% reported by Smigla et al. may be due to their re-dosing policy at 45 minutes. [3] Less frequent dosing allows the surgeon to work continuously and reduces the risk of contamination. Our data show lower levels of immediate postoperative complications and mortality when using MDN, but the differences are not statistically significant. Accelerated accumulation of intracellular Ca^{2+} during myocardial ischemia mediated reperfusion damage, which is observed during cardiac surgery.[10,11] Myocardial cell counteracts this high intracellular Ca^{2+} through energy requiring active transport mechanisms and eventually manifests itself as myocardial dysfunction during reperfusion. DN contains lidocaine, a membrane stabilizing agent that increases the blockade of the Na^{+} channel and minimizes its current potential. The solution Mg^{2+} content is acting as a Ca^{2+} antagonist. These are the mechanisms by which MDN cardioplegia protects the myocardium from high intracellular Ca^{2+}.[9]

Study limitations

More prospective long-term studies need to be designed to explore the applications of DN cardioplegia and confirm our current findings.

CONCLUSIONS

Evidence from this study suggests that the routine adult use of modified cardioplegic protection of del Nido may be safe, leads to comparable clinical outcomes, and accelerates the surgical process. The observed reduced incidence of new onset of postoperative arrhythmia, postoperative myocardial infarction, multiorgan failure and in-hospital mortality should be further studied, as it may imply superiority of myocardial protection with the modified solution. More prospective long-term studies should be designed to study the applications of MDN cardioplegia and confirm our current conclusions.

Competing Interests

The authors have declared that no competing interests exist.

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Холодовая модификация кардиоплегии Del Nido у пожилых пациентов, перенёсших плановую кардио-коронарную хирургию

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Резюме

Введение: Кардиоплегический раствор Kirklin (Kn) часто применяют у пожилых кардиохирургических больных. Это требует реинфузии через короткие промежутки времени, что вызывает дополнительные трудности во время операции и часто ставит под сомнение качество защиты миокарда.

Цель: Продемонстрировать, обеспечивает ли модифицированная кардиоплегия Del Nido (MDN) с более длительным периодом остановки сердца достаточно эффективную и надежную защиту миокарда по сравнению с классической кардиоплегией Kirklin, которую мы используем в нашем заведении.

Материалы и методы: Это амбиспективное клинико-эпидемиологическое исследование было проведено в отделении кардиохирургии Университетской больницы Святой Анны в Софии в период с января 2017 года по сентябрь 2021 года. С помощью генератора случайных чисел были отобраны сто двадцать пациентов, которые были разделены на две группы. по 60 пациентов в каждом. После дальнейшей обработки данных из группы Kirklin выбыли ещё пять пациентов из-за техники операции „бьющееся сердце“. В результате группы были разделены следующим образом: 1) интермиттирующая кардиоплегия Kirklin (Kn, n=55), применявшаяся у пациентов в период с января 2017 г. по июнь 2019 г., и 2) модифицированная кардиоплегия Del Nido (MDN, n=60), применяемая с июня. 2019 г. по сентябрь 2021 г.

Результаты: В данном исследовании мы представляем наш опыт применения кардиоплегии MDN у пациентов, перенёсших изолированное CABG, и сравниваем его с группой пациентов, получавших кардиоплегию Kn. Разница во времени пережатия и искусственного кровообращения обусловлена индивидуальными качествами и опытом хирургов. При использовании MDN увеличение интраоперационных сроков не только не выявило ухудшения послеоперационных результатов, не увеличило необходимость применения дополнительной дозы кардиоплегии, но и не выразилось в статистически значимой разнице. Кардиоплегия MDN показала достоверно меньшее использование инотропной поддержки (p<0.001) и IABP (p=0.029). Фракция MB креатининфосфокиназы при поступлении больных в отделение интенсивной терапии была достоверно меньше в группе Kirklin (p=0.045).

Заключение: Результаты показывают, что рутинное использование модифицированной кардиоплегической защиты Del Nido у пожилых пациентов может быть безопасным, приводит к сопоставимым клиническим результатам и может ускорить хирургический процесс. Снижение частоты интра- и послеоперационных осложнений, таких как шок постоянного тока, аритмия, инфаркт миокарда, полиорганная недостаточность и внутрибольничная смертность, требует дальнейшего изучения, поскольку это может означать превосходство защиты миокарда с помощью модифицированного раствора.

Ключевые слова

кардиохирургия, кардиопротекция, кардиоплегия Del Nido, модифицированная кардиоплегия Del Nido