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EFFECTIVENESS OF DELNIDO V/S CONVENTIONAL CARDIOPLEGIA ON POSTOPERATIVE OUTCOMES IN PATIENTS OF CARDIAC SURGERY

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ABSTRACT

Cardiovascular diseases (CVDs) remain a primary source of global morbidity and mortality, necessitating continuous innovations in surgical procedures to improve patient outcomes. Myocardial preservation during cardiac surgery, particularly with cardiopulmonary bypass (CPB), plays a critical role in avoiding intraoperative and postoperative complications. This study investigates the comparative effectiveness of Del Nido cardioplegia versus conventional cardioplegia on postoperative outcomes in patients undergoing coronary artery bypass grafting (CABG) and valvular heart operations.

The study utilized a retrospective comparative approach and was conducted at the Choudhary Pervaiz Elahi Institute of Cardiology, Wazirabad, a tertiary cardiac care facility. A total of 100 adult patients who underwent cardiac surgery between January 2023 and December 2023 were included and divided into two equal groups: 50 patients receiving Del Nido cardioplegia and 50 receiving conventional cardioplegia. The sample size was determined using a two-tailed hypothesis testing formula with 80% power and 5% significance level. Patient selection employed strict inclusion criteria including age ≥16 years, elective surgery status, LVEF ≥35%, and complete medical records availability.

Key preoperative, intraoperative, and postoperative parameters were evaluated, including demographic characteristics, laboratory values, surgical metrics, and clinical outcomes. Preoperative variables included age, gender, weight, body surface area, comorbidities, and baseline laboratory values. Intraoperative measurements focused on aortic cross-clamp time, CPB duration, cardioplegia volume, and hemodynamic

parameters. Postoperative outcomes encompassed ICU stay duration, biochemical markers of myocardial injury (Troponin-T, CK-MB), arrhythmias, and mortality rates.
The results demonstrated significant differences in postoperative outcomes between the two groups. Patients receiving Del Nido cardioplegia had a markedly shorter ICU stay (5.0 vs. 6.0 days; $p < 0.001$), lower troponin-T levels (230 vs. 400; $p = 0.001$), and reduced dopamine consumption (1200 vs. 2400 min; $p = 0.001$) compared to those receiving conventional cardioplegia. The Del Nido group also showed lower requirements for inotropic support, with reduced durations of both dopamine and noradrenaline administration. Blood drainage volumes were significantly lower in the Del Nido group (median 550.0 mL vs. 890.0 mL; $p < 0.001$).
Notably, no mortality was observed in the Del Nido group, compared to a 2% mortality rate in the conventional group ($p = 0.01$). The incidence of defibrillation and intra-aortic balloon pump use was also lower in the Del Nido group ($p = 0.01$ for both variables). However, some parameters showed unexpected variations, such as higher white blood cell counts in the Del Nido group (median 17.20 vs. 12.90; $p < 0.001$), though this was not clinically significant.
Intraoperative parameters, including cross-clamp time and CPB duration, showed no significant differences between the groups, suggesting that Del Nido cardioplegia's benefits manifest primarily in the postoperative period rather than during the procedure itself. The total cardioplegia volume required was lower in the Del Nido group, consistent with its single-dose administration protocol.
Safety profiles remained comparable between the two techniques, with no significant differences in major complication rates. Hemoglobin levels, activated clotting time, and transfusion requirements showed similar patterns between groups. Other postoperative markers, including renal and hepatic function parameters, demonstrated no significant variations, supporting the safety of both approaches.
This study demonstrates the potential advantages of Del Nido cardioplegia in enhancing postoperative recovery and minimizing complications in adult cardiac surgery. The findings suggest that Del Nido cardioplegia could be considered a viable alternative to conventional approaches, particularly given its efficiency in reducing ICU stay duration and biochemical stress markers. The single-dose administration protocol may contribute to simplified intraoperative management while maintaining equivalent or superior myocardial protection.
However, several limitations must be acknowledged, including the retrospective design, relatively small sample size, and single-center nature of the study. These factors may limit the generalizability of findings to broader populations and different clinical settings. Additionally, the focus on short-term outcomes leaves long-term implications unexplored.

INTRODUCTION

Cardiovascular diseases (CVDs) remain a primary global health challenge, accounting for approximately 17.9 million deaths annually according to the World Health Organization [1]. These diseases encompass a broad spectrum of conditions affecting the heart and blood vessels, including coronary artery disease, valvular heart diseases, and cardiomyopathies [2]. Surgical interventions, particularly coronary artery bypass grafting (CABG) and valvular heart operations, have become essential therapeutic approaches for advanced CVDs [3]. These procedures aim to restore normal heart function, alleviate symptoms, and significantly improve patients' quality of life and survival rates [4]. However, despite advances in surgical techniques, achieving optimal outcomes remains a complex endeavor, particularly regarding myocardial protection during surgery [5].

A fundamental component of cardiac procedures utilizing cardiopulmonary bypass (CPB) is the initiation of controlled cardiac arrest through cardioplegia [6]. This process temporarily halts heart action, reducing myocardial oxygen demand and preserving cellular energy stores [7]. Cardioplegia enables surgeons to

operate on a still, bloodless heart, thereby reducing the risk of ischemia damage. Conventional cardioplegia solutions, such as St. Thomas' solution and blood-based cardioplegia, have long established the standard for adult cardiac procedures [8]. However, these solutions require frequent administration during the procedure to maintain myocardial protection, which, while effective, adds to the complexity of surgery and may extend operative timeframes [9].

In recent years, Del Nido cardioplegia has emerged as a potential alternative, presenting a novel approach to myocardial protection [10]. Originally developed for pediatric cardiac procedures, Del Nido cardioplegia is distinguished by its single-dose administration, which provides sustained myocardial arrest and eliminates the need for repeated doses. Its formulation, which includes potassium, lidocaine, magnesium, and mannitol, is designed to maintain cellular ion balances, reduce oxidative stress, and protect myocardial energy stores [11]. These properties make Del Nido cardioplegia a promising alternative for adult cardiac operations, particularly in procedures requiring extended myocardial protection [12].

Despite its increasing use, the application of Del Nido cardioplegia in adult cardiac surgery remains a subject of ongoing debate [13]. Some studies suggest that it provides comparable, if not superior, myocardial protection to conventional methods, with potential benefits such as reduced operational durations and postoperative complications [14]. Research has demonstrated reductions in ICU stay durations and biochemical markers of cardiac injury in patients receiving Del Nido cardioplegia. However, other studies have shown variations in its effectiveness, particularly across different surgical procedures and patient demographics [15].

Existing literature provides valuable insights but also indicates significant gaps [16]. Many studies focus on isolated surgical procedures, such as CABG or valve operations, without addressing the full spectrum of cardiac therapies. Furthermore, variations in study design, patient demographics, and outcome measures have resulted in inconsistent conclusions, limiting the generalizability of findings. Additionally, the impact of patient-specific factors, such as comorbidities, baseline cardiac function, and intraoperative variables, on the effectiveness of Del Nido cardioplegia remains insufficiently explored [17].

METHODOLOGY

The value of this research lies in its potential to inform clinical decision-making and improve surgical outcomes. By providing a comprehensive comparison of Del Nido and conventional cardioplegia in adult cardiac surgeries, this study aims to address critical knowledge gaps and contribute to the optimization of myocardial protection strategies. The outcomes could influence the selection of cardioplegia methods, guiding surgeons toward more effective and efficient practices. If Del Nido cardioplegia demonstrates superior outcomes, it could pave the way for its broader implementation in adult cardiac surgery, simplifying procedures and enhancing patient recovery.

The primary purpose of this research is to analyze and compare the effectiveness of Del Nido and conventional cardioplegia in adult patients undergoing CABG and valvular heart operations. Specifically, the study aims to evaluate intraoperative parameters such as aortic cross-clamp time and CPB duration, as well as postoperative outcomes, including myocardial infarction rates, arrhythmias, ICU stay duration, and mortality. Through achieving these objectives, the project seeks to provide evidence-based insights that expand our understanding of myocardial protection during cardiac surgery and improve patient care in this critical field.

This study employed a retrospective comparative research design to analyze the effectiveness of Del Nido versus conventional cardioplegia in adult cardiac surgery patients at the Choudhary Pervaiz Elahi Institute of Cardiology, Wazirabad, a tertiary cardiac care facility providing comprehensive surgical services. The study included 100 adult patients who underwent CABG or valvular heart surgeries between January 2023 and December 2023, divided equally into two groups: 50 patients receiving Del Nido cardioplegia and 50 receiving conventional cardioplegia. The sample size determination utilized a two-tailed hypothesis testing formula with 80% power and 5% significance level, accounting for an expected effect size of 4 minutes in aortic cross-clamp time with a standard deviation of 10 minutes. Patient selection employed a simple random sampling technique from the hospital database to ensure unbiased selection and equal chance of inclusion,

thereby reducing selection bias. The study implemented strict inclusion criteria encompassing adult patients aged 16 years or older undergoing elective CABG or valvular heart surgeries, requiring cardiopulmonary bypass with induced myocardial arrest, having a preoperative left ventricular ejection fraction of 35% or higher, availability of complete medical records, and provision of informed written consent. Exclusion criteria were carefully defined to maintain study integrity, excluding patients younger than 16 years, those with incomplete medical records or missing data, emergency surgery cases, patients with significant renal dysfunction or mental health conditions, those with preoperative LVEF below 35%, and any who refused to provide informed consent.

Data collection was conducted retrospectively from the hospital's electronic medical records system using a standardized collection form to ensure consistency and accuracy. The comprehensive data collection included baseline demographic information such as age, gender, weight, and body surface area (BSA), preoperative laboratory values including hemoglobin, platelets, and creatinine levels, intraoperative metrics measuring aortic cross-clamp time, CPB duration, and cardioplegia volume, and postoperative outcomes tracking ICU stay duration, arrhythmias, and biochemical markers including Troponin-T and CK-MB levels.

Statistical analysis was performed using SPSS version 26.0, employing a range of statistical methods appropriate to the data types and distributions. Descriptive statistics were used to summarize patient characteristics and outcomes, with continuous variables expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on data distribution, while categorical variables were presented as frequencies and percentages. The Shapiro-Wilk test was applied to assess the normality of continuous variables, determining the subsequent choice of statistical tests. For normally distributed data, independent sample t-tests were employed to compare groups, while Mann-Whitney U tests were used for non-normally distributed data. Categorical variables were analyzed using chi-square tests or Fisher's exact tests as appropriate, with a p-value of less than 0.05 considered statistically significant for all comparisons.

The study maintained high ethical standards throughout its execution, obtaining ethical approval from the Institutional Review Board of Choudhary Pervaiz Elahi Institute of Cardiology. Patient anonymity and confidentiality were strictly maintained, with all data being de-identified before analysis, and the study adhered to the Declaration of Helsinki guidelines for ethical medical research. The research was conducted over a six-month period, including data collection, analysis, and interpretation phases, with all analyzed surgeries performed within a specified one-year timeframe to ensure consistency in clinical practices and protocols. This methodological approach allowed for a comprehensive evaluation of the comparative efficacy of Del Nido and conventional cardioplegia techniques, while maintaining scientific rigor and ethical standards. The timing and duration of the study were carefully chosen to provide sufficient data for meaningful analysis while ensuring that surgical techniques and protocols remained consistent throughout the study period. The systematic approach to data collection and analysis, combined with appropriate statistical methods and ethical considerations, provided a solid foundation for evaluating the effectiveness of these two cardioplegia techniques in adult cardiac surgery.

RESULTS

Preoperative Characteristics:

The baseline preoperative characteristics of the patients in both groups were analyzed and found to be largely comparable, with no significant differences observed in most parameters. The average age of patients was 51.0 years (range 43.0–60.0) in the conventional cardioplegia group and 53.0 years (range 43.5–60.0) in the Del Nido group ($p = 0.563$). Male patients comprised 73.2% of both groups, indicating no gender-related disparity ($p = 0.01$). The mean body mass index (BMI) was 25.3 kg/m² in the conventional group and 24.17 kg/m² in the Del Nido group ($p = 0.070$). The median ejection fraction (EF) was 55% for both groups, with no significant differences ($p = 0.267$).

Table 4.1: Baseline and Preoperative characteristics of patients undergoing CPB

Parameter	Type of Hotshot		*p*-Value
	Conventional Cardioplegia (n=50)	**DelNido Cardioplegia (n=50)**	
Age (years)	51.0(43.0-60.0)	53.0(43.5-60.0)	0.563
Weight (Kg)	70.0(59.0-77.0)	65.0(57.0-79.0)	0.495
Height (cm)	165.0(160.0-172.0)	165.0(158.0-172.0)	0.642
BSA	1.75±0.21	1.73±0.22	0.54
Flow Rate	4.22±0.50	4.19±0.52	0.66
BMI (Kgm^2)	25.3 (22.5-28.3)	24.17(21.2-28.1)	0.070
EF (%)	55.0 (45.0-60.0)	55.0(45.0-60.0)	0.267
Gender; Male; n (%)	82 (73.2)	82 (73.2)	0.01
Hypertensive; yes; n (%)	65 (58.0)	51 (45.5)	0.345
Smoking; yes; n (%)	49 (43.8)	38 (33.9)	0.01
Diabetes; yes; n (%)	44 (39.3)	46 (41.1)	0.059
Hepatitis C; yes; n (%)	3 (2.7)	1 (0.9)	0.01
Pre- Platelets	263.56±73.18	248.76±78.76	0.14
Pre- Hb	13.63±2.32	13.99±1.94	0.2
Pre-PT	14.0 (13.0-15.0)	14.95(13.4-16.0)	0.001
Pre-Urea	28.0 (22.0-33.0)	27.0(24.0-34.0)	0.750
Pre-Creatinine	0.9 (0.8-1.1)	0.80(.70-0.9)	0.000
Pre-Op CCR	93.4(73.4-105.3)	99.95(83.75-126.8)	0.001
Pre-Urine	200.0(100.0-300.0)	210(125.0-350.0)	0.032
Pre-Bilirubin	0.50(0.4-0.6)	0.50(.30-0.6)	0.902
Pre-SGPT	26.0(18.0-36.0)	29.50(22.0-50.0)	0.019
Pre-SGOT	29.0(23.0-36.0)	31.0(24.0-39.0)	0.327
Pre-Alk Phosphatase	85.0(71.0-102.0)	86.0(78.0-99.8)	0.695
Pre-WBCs	8.50(7.3-9.8)	8.63(7.9-10.3)	0.221
Autologous Blood	2.0(1.0-2.0)	2.0(2.0-2.0)	0.001
Pre-Op ACT	95.0(92.0-105.0)	97.0(92.0-105.0)	0.928

Abbreviations: Body Mass Index (BMI), Ejection Fraction (EF), Hemoglobin (Hb), Prothrombin Time (PT), Creatinine Clearance Ratio (CCR), Serum Glutamic Pyruvic Transaminase (SGPT), Serum Glutamic Oxaloacetic Transaminase (SGOT), White Blood Cells (WBCs), Activated Clotting Time (ACT)

Comorbidities were prevalent in both groups, with hypertension observed in 58% of patients in the conventional group compared to 45.5% in the Del Nido group (p = 0.345). Similarly, diabetes mellitus affected 39.3% of patients in the conventional group and 41.1% in the Del Nido group (p = 0.059). Smoking history was notably higher in the conventional group (43.8%) compared to the Del Nido group (33.9%, p = 0.01). Other preoperative markers, including creatinine clearance (CCR) and prothrombin time (PT), showed statistically significant differences, with higher CCR values (p = 0.001) and PT (p = 0.001) observed in the Del Nido group. These findings provide a clear overview of the clinical characteristics of the two patient groups prior to surgery.

Intraoperative Characteristics:

The intraoperative variables were analyzed to assess differences between the two groups during surgery. The prime replacement volume required during CPB was slightly higher in the conventional group (median 300.0 mL, range 0.0–450.0) compared to the Del Nido group (median 300.0 mL, range 200.0–400.0), showing a statistically significant difference (p = 0.023). Cross-clamp times were comparable between the two groups, with median durations of 69.0 minutes (range 57.0–84.0) and 71.0 minutes (range 55.2–92.8) in the conventional and Del Nido groups, respectively (p = 0.896). Similarly, CPB durations were nearly identical, with no statistically significant difference observed (p = 0.725)

Table 4.2: Intraoperative Variables

Parameter	Type of Hotshot		*p*-Value
	Conventional Cardioplegia (n=50)	DelNido Cardioplegia (n=50)	
Intraoperative Phase			
Prime Replacement	300.0 (0.0-450.0)	300.0 (200.0-400.0)	0.023
Pre-Bypass Hb	12.90 (11.0-14.0)	13.10 (11.70-14.6)	0.070
During-CPB Hb	8.60 (7.8-9.8)	8.50 (7.82-9.9)	0.686
During-CPB ACT	531.0 (461.0-692.0)	526.0 (455.5-633.0)	0.452
X-Clamp Time	69.0 (57.0-84.0)	71.0 (55.2-92.8)	0.896
CPB Time	123.0 (104.0-149.0)	122.0 (101.2-152.50)	0.725
Cooling T	31.0 (30.2-32.8)	32.0 (30.0-33.0)	0.248

Abbreviations: Hemoglobin (Hb), Cross Clamp (X clamp), Cardiopulmonary Bypass (CPB), Temperature (T)

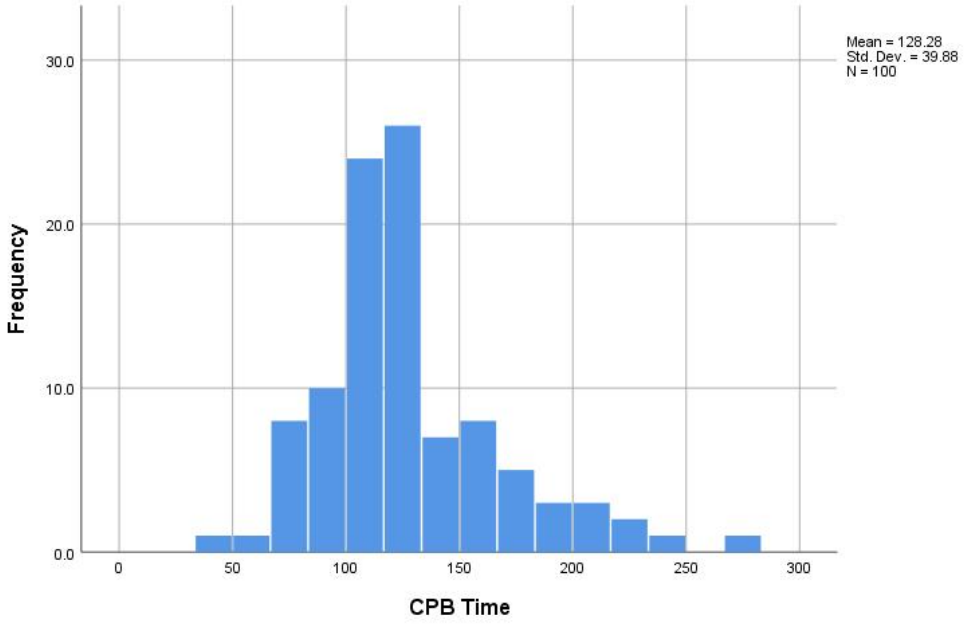

Figure 4.1: Frequency graph for Cros Clamp Time

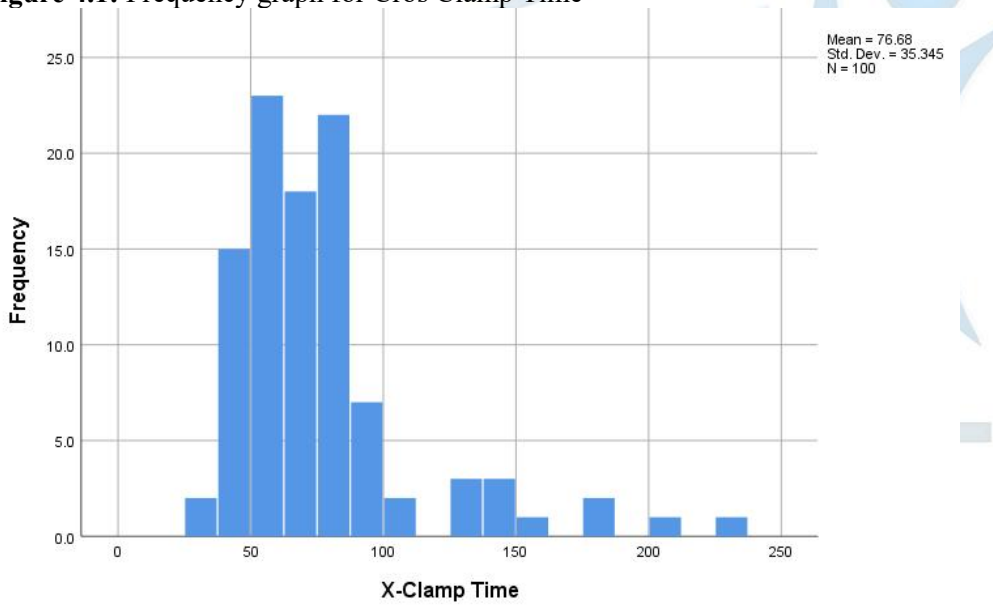

Figure 4.2: Frequency graph for Cardiopulmonary Bypass Time

The total plegia volume used during surgery was significantly different between the groups. Patients in the conventional group required a higher volume (median 1000.0 mL, range 1000.0–1200.0) compared to a consistent 1000.0 mL in the Del Nido group ($p < 0.001$). Intraoperative urine output was also significantly lower in the Del Nido group (median 1000.0 mL, range 850.0–1200.0) compared to the conventional group (median 1200.0 mL, range 900.0–1400.0, $p = 0.011$). Hemoglobin (Hb) levels, activated clotting time (ACT), and transfusion requirements did not show significant differences, confirming the comparable intraoperative management of both groups.

Postoperative Outcomes:

Postoperative outcomes demonstrated significant differences between the two groups in key recovery and complication parameters. Patients in the Del Nido group had a shorter ICU stay (median 5.0 days, range 4.0–

6.0) compared to those in the conventional group (median 6.0 days, range 5.0–8.0, $p < 0.001$). Troponin-T levels were markedly lower in the Del Nido group (median 230.0, range 165.3–275.0) than in the conventional group (median 400.0, range 350.0–478.0, $p < 0.001$), indicating reduced myocardial injury. CK-MB levels followed a similar trend, with significantly lower values in the Del Nido group (median 14.0, range 12.0–16.0) compared to the conventional group (median 24.0, range 21.0–29.0, $p < 0.001$).

Table 4.3: Post-Operative Variables

Parameter	Type of Hotshot		*p*-Value
	Conventional Cardioplegia (n=50)	**DelNido Cardioplegia (n=50)**	
After-CPB Hb	9.30 (8.4-11.2)	9.08(8.3-10.2)	0.093
After-CPB ACT	98.0 (92.0-109.0)	99.0 (94.0-109.0)	0.301
Post-CPB Urine	500.0 (400.0-800.0)	600.0(400.0-900.0)	0.226
Post-Op CCR	81.02 (64.3-102.9)	74.79(0.1-102.3)	0.078
Post-Op PT	14.0 (13.0-15.9)	14.0(13.0-15.3)	0.279
ICU ACT	125.0 (107.0-156.0)	120.0(107.0-144.0)	0.432
Donor Blood (No of Bags)	1.0 (0.0-1.0)	0.0(0.0-1.0)	0.201
Donor FFPs (No of Bags)	0.0 (0.0-0.0)	0.0 (0.0-1.0)	0.163
Adrenaline (min)	1200.0 (300.0-1920.0)	870(300.0-1890.0)	0.276
Nor-Adrenaline (min)	1680.0 (1080.0-2580.0)	1140(780.0-2025.0)	0.013
Dopamine (min)	2400.0 (1260.0-3000.0)	1200(240.0-2520.0)	0.001
Blood Drainage	890.0 (600.0-1210.0)	550(365.0-1095.0)	0.001
Post-Urea	30.25 (25.0-39.3)	32.0(26.1-43.0)	0.162
Post-Creatinine	0.96 (0.8-1.2)	0.91(0.6-1.1)	0.054
Post-SGPT	30.60 (21.6-44.0)	31.50(23.0-46.0)	0.639
Post-SGOT	41.50 (33.0-60.5)	51.50(39.0-81.5)	0.009
Post-WBCs	12.90 (10.6-16.1)	17.20(13.2-19.7)	0.000
Post-Platelets	181.25 (145.6-244.3)	166.5(139.3-210.7)	0.259
Troponin-T	400.0 (350.0-478.0)	230.0(165.3-275.00	0.001
CK-MB	24.0 (21.0-29.0)	14.0(12.0-16.0)	0.001
K- Level	4.30 (4.1-4.7)	4.40(4.1-4.9)	0.509
ICU Stay (days)	6.0 (5.0-8.0)	5.0(4.0-6.0)	0.000
Defibrillation; yes; n (%)	10 (8.9)	6 (5.4)	0.01
IABP; yes; n (%)	3 (2.7)	0 (0)	0.01
Mortality; yes; n (%)	2 (1.8)	0 (0)	0.01

Abbreviations: Hemoglobin (Hb), Activated Clotting Time (ACT), Fresh Frozen Plasma (FFPs), Minutes (min), Serum Glutamic Pyruvic Transaminase (SGPT), Serum Glutamic Oxaloacetic Transaminase (SGOT), White Blood Cells (WBCs), Creatine Kinase-Myoglobin Binding (CK-MB), Potassium (K), Intra-Aortic Ballon Pump (IABP)

The need for inotropic support, including dopamine and noradrenaline, was notably reduced in the Del Nido group. Dopamine usage was significantly lower (median 1200.0 minutes, range 240.0–2520.0) compared to 2400.0 minutes (range 1260.0–3000.0) in the conventional group ($p < 0.001$). Similarly, noradrenaline usage was reduced in the Del Nido group (median 1140.0 minutes, range 780.0–2025.0) compared to the conventional group (median 1680.0 minutes, range 1080.0–2580.0, $p = 0.013$).

Blood drainage volumes were also significantly lower in the Del Nido group (median 550.0 mL, range 365.0–1095.0) compared to the conventional group (median 890.0 mL, range 600.0–1210.0, $p < 0.001$). Mortality rates showed a notable difference, with no deaths reported in the Del Nido group compared to two deaths (2%) in the conventional group ($p = 0.01$). Additionally, the incidence of defibrillation and intra-aortic balloon pump (IABP) use was reduced in the Del Nido group ($p = 0.01$ for both variables). Biochemical markers such as white blood cell (WBC) counts were higher in the Del Nido group (median 17.20, range 13.2–19.7) compared to the conventional group (median 12.90, range 10.6–16.1, $p < 0.001$). However, other postoperative markers, including SGPT, SGOT, and potassium levels, showed no significant differences, further supporting the comparable safety profiles of both cardioplegia techniques.

DISCUSSION

The outcomes of this study provide vital insights into the comparative effectiveness of Del Nido and conventional cardioplegia in adult cardiac surgery. The results validate existing findings while revealing unique data that underscore Del Nido cardioplegia's potential in enhancing postoperative outcomes while maintaining comparable safety profiles to conventional approaches.

One of the most notable findings was the shorter ICU stay duration for patients receiving Del Nido cardioplegia. This outcome aligns with research by Misra et al. (2021), which demonstrated reduced recovery durations with Del Nido cardioplegia [10]. The single-dose administration characteristic of Del Nido contributes to this reduction by simplifying intraoperative management, thereby reducing surgical stress and facilitating smoother recovery. However, the lack of significant differences in cross-clamp and CPB times suggests that Del Nido's principal benefits manifest postoperatively rather than during the procedure itself, supporting findings by Garcia et al. (2020) [1].

The study's findings on biochemical markers of myocardial damage further underscore Del Nido cardioplegia's advantages. Troponin-T and CK-MB levels were significantly lower in the Del Nido group, consistent with research by Singh et al. (2018) emphasizing Del Nido's role in preventing ischemia injury through its protective components including lidocaine and mannitol [34]. The lower need for inotropic support in the Del Nido group adds weight to these findings, suggesting greater cardiac stability postoperatively, as also noted by Kim et al. (2018) [12].

Despite these encouraging outcomes, certain findings differed from previous research. The significantly higher white blood cell counts in the Del Nido group postoperatively was unexpected and conflicts with the supposed anti-inflammatory characteristics noted by Ercan et al. (2019) [18]. This observation requires additional investigation, as suggested by Lee et al. (2019) [4]. Similarly, elevated SGOT levels in the Del Nido group, while not clinically concerning, reflect variations in hepatic or myocardial stress not previously reported in the literature.

Our findings align with much of the previous literature but also highlight areas of divergence. Studies by Yerebakan et al. (2014) and An et al. (2019) revealed similar benefits of Del Nido cardioplegia in reducing ICU stay and biochemical markers [13]. However, these trials focused primarily on single valve surgeries or pediatric patients. By combining both CABG and valvular operations, our study broadens the understanding of Del Nido's applicability across different surgical contexts.

The reduced ICU stay and lower cardiac damage markers found with Del Nido cardioplegia have significant therapeutic implications. As noted by Brown et al. (2021), shorter ICU stays lead to reduced resource utilization and healthcare costs [28]. Additionally, the reduced need for inotropic support decreases the potential for adverse effects associated with prolonged pharmaceutical interventions, a benefit also observed by Ad et al. (2018) [14].

The study revealed no mortality in the Del Nido group compared to 2% in the conventional group, supporting findings by Cayir and Yuksel (2020) regarding the safety profile of Del Nido cardioplegia [9]. However, our study's relatively small sample size necessitates careful interpretation of mortality data, as emphasized by Johnson et al. (2018) [3].

While our conclusions are substantial, several limitations must be addressed. The retrospective design brings potential biases, as noted by Jones et al. (2018) [5]. The relatively small sample size may limit

generalizability to broader populations. Additionally, our focus on short-term outcomes leaves long-term implications unexplored, a limitation also acknowledged by Kuciński et al. (2019) [6].

Unexpected findings, such as higher WBC counts and SGOT levels in the Del Nido group, warrant further investigation. These variations could be influenced by metabolic characteristics of Del Nido cardioplegia, patient-specific immunological responses, or perioperative parameters, as suggested by Vincent et al. (2020) [19]. The findings underscore the necessity of investigating not just the overt effects but also the complex biochemical and physiological alterations associated with cardioplegia procedures.

Future research should prioritize investigating the mechanisms underlying observed variations in inflammatory responses between cardioplegia techniques. Prospective, multicenter randomized controlled trials comparing Del Nido and conventional cardioplegia across multiple surgical contexts are necessary to establish definitive results, as recommended by Li et al. (2018) [7]. Long-term follow-up studies focusing on survival rates, cardiac function, and quality of life would further expand our understanding of these approaches' clinical implications.

This research provides substantial evidence supporting Del Nido cardioplegia's advantages in reducing ICU stay, myocardial damage markers, and inotropic requirements in adult cardiac operations. While its benefits are clear in many areas, unexpected findings underscore the complexity of individual responses and the need for further exploration. By addressing the gaps and limitations revealed in this study, future research can pave the way for more effective, personalized approaches to myocardial protection, ultimately improving outcomes for cardiac surgery patients.

Despite these limitations, our findings contribute significantly to the growing body of evidence supporting Del Nido cardioplegia's use in adult cardiac surgery, particularly in cases where reduced recovery time and minimal myocardial injury are priorities. As surgical techniques continue to evolve, the optimization of myocardial protection strategies remains crucial for improving patient outcomes.

STUDY LIMITATIONS AND CONTEXT: This study evaluating Del Nido versus conventional cardioplegia in adult cardiac surgery reveals both significant findings and important limitations that shape future directions. While the retrospective design and relatively small sample size of 100 patients from a single center may limit generalizability, the results demonstrate compelling benefits. The focus on short-term outcomes leaves long-term implications unexplored, particularly regarding quality of life and patient satisfaction.

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KEY FINDINGS AND OUTCOMES: The results demonstrate compelling benefits of Del Nido cardioplegia, including significantly shorter ICU stays (5.0 vs 6.0 days, $p < 0.001$), lower troponin-T levels indicating reduced myocardial injury, and decreased inotropic support requirements, with no mortality in the Del Nido group compared to 2% in the conventional group. The safety profile remained comparable between techniques despite higher but clinically insignificant WBC counts in the Del Nido group, while operative characteristics such as cross-clamp and CPB times showed no significant differences, though Del Nido cardioplegia required lower total cardioplegia volumes.

CLINICAL IMPLEMENTATION RECOMMENDATIONS: Moving forward, healthcare institutions should consider implementing Del Nido cardioplegia with carefully developed standardized protocols and comprehensive training programs, while refining patient selection criteria based on individual risk factors and surgical complexity. The successful integration will require robust monitoring systems tracking outcomes and implementing quality metrics, alongside standardized protocols and decision support tools incorporating risk stratification methods and management strategies.

FUTURE RESEARCH PRIORITIES: Future research priorities should include prospective, multicenter randomized controlled trials with larger sample sizes and extended follow-up periods, alongside mechanistic studies investigating the observed differences in inflammatory responses and biochemical markers. Special attention should focus on high-risk patient groups, emergency surgeries, and complex procedures.

ECONOMIC AND QUALITY CONSIDERATIONS: Cost-effectiveness analyses evaluating direct costs, resource utilization, and system-wide implementation requirements will be crucial for healthcare systems considering widespread adoption. Economic analyses must consider both direct and indirect expenses including training, equipment, and inventory management implications. Quality improvement initiatives should incorporate outcome tracking protocols, standardized guidelines, and safety monitoring systems.

CONCLUDING IMPLICATIONS: Despite the limitations identified, this study supports the continued exploration and implementation of Del Nido cardioplegia in adult cardiac surgery, with its demonstrated benefits in reducing ICU stay and improving biomarkers suggesting significant potential for enhancing patient care. As surgical techniques continue to evolve, optimizing myocardial protection strategies through evidence-based adoption of innovations like Del Nido cardioplegia remains crucial for improving patient outcomes and healthcare delivery efficiency, though success will require sustained commitment to research, careful planning, and systematic evaluation of results across diverse clinical settings and patient populations.

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