Volume 4, Issue 3, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

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

Muhammad Umair Hameed[1], Muhammad Noman Rafique[*2], Syeda Amna Tahir[3], Noor Fatima[4], Nayab Zahra[5], Adrees Sultan[6]

[1]*Department of Health Professional Technology, The University of Lahore, Lahore, Pakistan*
[*2]*Demonstrator, Department of Health Professional Technology, The University of Lahore, Lahore, Pakistan*
[3]*Shalamar Institute of Health Sciences, Shalamar Medical & Dental College, Lahore, Pakistan*
[4]*Chaudhry Pervaiz Elahi Institute of Cardiology, Wazirabad, Pakistan*
[5]*Punjab Institute of Cardiology, Lahore, Pakistan*
[6]*Anglia Ruskin University, Cambridge, United Kingdom*

[1]umairhameed767@gmail.com, [*2]noman.rafique@dhpt.uol.edu.pk, [3]amnatahir1227@gmail.com, [4]noorfatimawajid23@gmail.com, [5]nznayaab@gmail.com, [6]adreessultan@gmail.com

DOI: https://doi.org/10.5281/zenodo.21370690

Keywords
Cardioplegia, Delnido Cardioplegia, Conventional Cardioplegia, Cardiac Surgery, Myocardial Protection

Article History
Received: 01 February 2026
Accepted: 17 March 2026
Published: 31 March 2026

Copyright @Author
Corresponding Author: *
Muhammad Noman Rafique

Abstract

Background: *Cardiovascular diseases remain the leading cause of morbidity and mortality worldwide, resulting in an increasing demand for effective myocardial protection strategies during cardiac surgery. Cardioplegia plays a crucial role in minimizing ischemia-reperfusion injury during cardiopulmonary bypass. Del Nido cardioplegia, originally developed for pediatric cardiac surgery, has gained increasing acceptance in adult cardiac procedures because of its prolonged myocardial protective effects. This study aimed to compare the effectiveness of Del Nido cardioplegia with conventional cardioplegia in adult patients undergoing coronary artery bypass grafting and valvular heart surgery.*

Methodology: *A retrospective comparative study was conducted at a tertiary cardiac care hospital. A total of 136 adult patients were included, comprising 68 patients who received Del Nido cardioplegia and 68 patients who received conventional cardioplegia. Demographic characteristics, intraoperative variables, postoperative biochemical markers, intensive care unit stay, inotropic support requirements, postoperative blood loss, major complications, and renal and hepatic biochemical parameters were obtained from hospital medical records. Statistical analysis was performed using SPSS version 26.0, with a p-value of <0.05 considered statistically significant.*

Results: *Patients receiving Del Nido cardioplegia demonstrated significantly shorter aortic cross-clamp time (69 vs. 74 minutes; $p = 0.041$) and cardiopulmonary bypass duration (121 vs. 129 minutes; $p = 0.032$) compared with the conventional cardioplegia group. Del Nido cardioplegia was associated with a significantly shorter ICU stay (5 vs. 6 days; $p = 0.002$), lower postoperative Troponin-T (228 vs. 392 ng/L; $p < 0.001$) and CK-MB (15 vs. 24 U/L; $p < 0.001$) levels, reduced inotropic support, decreased postoperative blood loss, fewer major postoperative complications, and improved postoperative renal and hepatic biochemical profiles.*

Conclusion: *Del Nido cardioplegia demonstrated superior myocardial*

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

protection and improved early postoperative outcomes compared with conventional cardioplegia in adult patients undergoing CABG and valvular heart surgery. Its use was associated with improved operative efficiency, reduced myocardial injury, enhanced postoperative recovery, and lower complication rates. These findings support Del Nido cardioplegia as a safe and effective myocardial protection strategy in adult cardiac surgery. Further large-scale prospective multicenter studies are recommended to validate these findings and evaluate long-term clinical outcomes.

INTRODUCTION

Cardiovascular diseases (CVDs) are the main cause of morbidity and mortality and remain a significant burden to the health care systems around the world[1]. The World Health Organization (WHO) estimates that about 17.9 million people worldwide die each year from cardiovascular diseases, making up almost 32% of all deaths [2]. Cardiac surgeries like coronary artery bypass grafting (CABG) surgeries and valvular heart surgeries have been found to be indispensable interventions to improve survival and quality of life in patients with advanced cardiac disorders [3]. Although huge progress has been made in the area of surgery, anesthesia and postoperative critical care, myocardial protection during cardiac surgery is one of the most important factors relating to the postoperative recovery and survival[4].

In cardiac surgery during cardiopulmonary bypass (CPB), the heart is deliberately stopped to allow for a "bloodless" surgical field as well as precise surgical maneuver during surgery[5]. But at this time, stopping coronary supply puts myocardium at risk of ischemic injury and lead to postoperative complications such as arrhythmias, myocardial infarction, low cardiac output syndrome (LCOTS), prolonged intensive care unit (ICU) stay and increased mortality[6]. Thus, providing sufficient myocardial protection using cardioplegia solutions becomes very important in reducing the ischemic damage and maintaining cardiac function during surgery[7].

Cardioplegia is the delivery of special solutions to arrest the heart briefly in order to avoid the ischemic/reperfusion damage to the myocardial tissue[8]. The standard myocardial protection techniques comprise of conventional cardioplegia (CC) solutions (blood based or crystalloid including St. Thomas' solution) which have been used in adult cardiac surgery for decades. While these traditional techniques are successful, they can involve repeated application of these drugs during surgery to maintain myocardial arrest and protection, which can produce a longer operative time and potential for electrolyte imbalance and myocardial edema[10]. Further, the need to repeatedly interrupt the operation to prepare the patient for cardioplegia can reduce the efficiency of the operation and cause an increase in myocardial strain when the procedure is lengthy[11].

To overcome these limitations, Del Nido cardioplegia was developed for use initially for the pediatric cardiac surgery and has become a more recent focus for adult cardiac surgery[12]. Del Nido cardioplegia is a single dose cardioplegia containing K, Lidocaine, Mg and Mannitol which is utilized for longer, more prolonged ischemic periods[13]. Through its formulation it helps to maintain ionic balance in the cells, reduce excess calcium in the cells, minimize oxidants, and improve the preservation of the heart during CPB[14]. Del Nido cardioplegia has the benefit of causing prolonged cardiac arrest and allowing only one dose of administration of up to 60 – 90 minutes without the need to re-administered throughout surgery.

There are several studies where the efficacy of Del Nido cardioplegia have been examined in adult patients undergoing CABG and valvular heart surgery[16]. Using existing evidence, Del Nido cardioplegia appears to help decrease myocardial markers of postoperative myocardial injury, including troponin-T and CK-MB; reduce the need for inotropic support; decrease the length of the ICU stay; and improve overall postoperative recovery[17]. In addition, often needed

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

interruptions during surgery can be reduced, which can help optimize surgical procedures and shorten surgical times. Nevertheless, there are contrasting reports in the literature about its superiority over conventional cardioplegia in adult cardiac surgery[19]. Some studies have, however, reported better postoperative results with Del Nido cardioplegia, and others have found no statistical differences between the two techniques regarding the operability time, complications or deaths[20].

With the rise of cardiovascular diseases and rising numbers of cardiac surgeries for adults around the world, new myocardial protection techniques are needed to maximize surgical success and minimize complications[21]. Good myocardial preservation will not only advocate for the lifesaving of patients, but also to minimize dependency on ICUs, minimize hospital stay, and decrease health care cost parameters related with prolonged post-operative intensive care management[22]. In countries like Pakistan, with scarce medical resources and a rising demand for cardiac surgery, the importance of finding an efficient and safe technique of cardioplegia could be amplified for better healthcare and less burden on healthcare facilities[23].

Significant peri-operative and post-peri-operative parameters such as cross clamp time, cardiopulmonary bypass time, biomarkers of myocardial injury, ICU length of stay, postoperative complications, arrhythmia, and death are assessed. Intraoperative and postoperative parameters such as postoperative complications, arrhythmias, mortality, myocardial injury biomarkers, cross-clamp time, and cardiopulmonary bypass time are assessed. Evaluation of these clinical parameters will contribute to the question whether Del Nido cardioplegia is superior in myocardial protection and postoperative recovery than traditional methods.

The significance of this study is to find a practical application of the same in the process of evidence based clinical decision making in cardiac surgery in adult patients. Comparative studies of fruits and local data evaluating the effectiveness of Del Nido cardioplegia in various patient groups and diverse clinical settings is needed as Del Nido cardioplegia is becoming more popular in the adult population. Results of this study might help cardiac surgeons, cardiac perfusionists and practitioners to decide which cardioplegia technique is most suitable for adult cardiac surgeries. In addition, the superior results that can be obtained with Del Nido cardioplegia might encourage use of this technique in adult cardiac surgery up front, thereby improving postoperative recovery and reducing morbidity rates[26].

There have been several international studies on Del Nido cardioplegia, but there is very little local research done comparing its effectiveness against the conventional cardioplegia in adult subjects with CABG and valvular surgeries. Improvements in patient selection, surgical techniques, and medical infrastructure could affect patient outcomes, so it is important to apply these techniques in the local medical setting. Hence, the purpose of this study was to fill this gap and offer more data on the safety, efficacy and applicability of Del Nido cardioplegia in adult cardiac surgery. The study aims to provide valuable insights into optimizing myocardial protection strategies and improving patient outcomes in cardiac surgery, by comparing postoperative outcomes across the two cardioplegia types.

1.1: RATIONALE

Although there have been great improvements in cardiac surgical techniques and management of the perioperative patient, myocardial protection is a continuing challenge in cardiac surgery. Traditional cardioplegia has been the accepted method of myocardial protection, but it also involves the use of a multitude of doses and can contribute to increased surgical interruption time, myocardial damage, and late post-operative recovery. Recently, Del Nido cardioplegia has been suggested as an alternative, which may have beneficial effects such as; myocardial protection time, less myocardial injury, less time in the intensive care unit, and less requirement for inotropic support. While the effectiveness of Del Nido for adult cardiac surgery has been investigated in a few studies internationally, the findings have been varied and there is a paucity of

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

local data comparing Del Nido with conventional cardioplegia for adult surgery involving coronary artery bypass grafting (CABG) and valvular heart surgery. Thus, this study was designed to assess and compare the postoperative results of these two different cardioplegia techniques with the aim of establishing a safer and more effective protective method for the heart for adult patients undergoing cardiac surgery.

2. LITERATURE REVIEW

CVDs manifest as the leading cause of death and disease worldwide and millions of people suffer from them yearly. As therapy becomes increasingly demanded, so becomes myocardial protection in cardiac surgery.[27] One of the most widely used approaches for cardiac protection during surgery is transient cardiac arrest (transient cardiac arrest by cardioplegia), which has been shown to reduce myocardial oxygen consumption and the occurrence of ischemic injury. Many formulations of cardioplegia have been suggested over the years, the most traditional cardioplegic solutions being crystalloid (e.g., St. Thomas' solution) and blood-based solutions.[28] Such solutions have remained the gold standard for many years as they only need to be administered multiple times to protect myocardium during surgery. However, advancements in developing cardioplegic solutions, such as the use of Del Nido cardioplegia, have led to new thinking about how to further enhance myocardial cytoprotecting and possibly enhance patient outcomes in cardiac surgery.[29]

Cardioplegia, or myocardial protection, began to be introduced several decades ago, a first being the blood-based cardioplegia solutions. These fluid therapies, consisting of primarily blood and electrolytes, were developed to decrease myocardial oxygen use and provide myocardial protection under conditions of ischemia. Blood-based cardioplegia solutions have a number of advantages, but are also associated with specific problems, including the requirement of a multiple injection during administration, electrolyte disorders.[30] etc. This sparked an interest into looking at adjunct options that may be able to offer long-term protection of the myocardium with less need for intervention. One such invention was crystalloid cardioplegia, which provided similar advantages to blood-based therapies, but unlike blood-based therapies did not require blood, with the accompanying risks.

St. Thomas' solution is the most popular crystalloid cardioplegia, and the standard of care in most cardiac surgeries. Developed in the 1970s, the solution contains potassium, magnesium and others to produce cardiac arrest. Although St. Thomas solution has been able to shorten ischemic time and protect the myocardium before and after surgery; multiple doses are required during surgery to ensure myocardial protection.[31] More recent revolutions of Del Nido cardioplegia were the provision of cardioplegia solutions downstream as single doses. The crystalloid solution used was Del Nido "cardioplegia" and this has proved to be effective in cardiac surgery for adults as well. With the combination of potassium, lidocaine, magnesium and mannitol in a single dose administration, continuous cardiac protection is adhered for longer procedures, reducing the need for re-dosing, and to increase surgery efficiency.[32]

They are the first studies to evaluate Del Nido cardioplegia for children, where it was initially developed. According to the currently available evidence (up to 10/2023) during congenital heart operations Del Nido cardioplegia adequately protects the myocardium with significant advantages of reducing the volume of ischemic injury, and increasing surgeon time, reducing surgical times, thus leading to improved recovery outcomes. Research by Misra et al. (2021) has endorsed the use of Del Nido cardioplegia due to achieving lower parameters of myocardial infarction (Troponin and CK-MB) as compared to the conventional blood-based cardioplegia formulation used in pediatric population.[33] Also, some improvements in the intensive care unit (ICU) length of stay have been found in patients receiving Del Nido cardioplegia, along with fewer arrhythmia events, indicating that this type of cardioplegia may be beneficial.

The following successful application of Del Nido cardioplegia in the surgical field in pediatrics has led to increased research interest by numerous

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

authors of possibly using this type of cardioplegia in surgical venues in the adult population, specifically in coronary artery bypass grafting (CABG) and valvular heart surgery.[34] A unique characteristic of Del Nido is the ability to provide long-lasting myocardial protection with a single bolus of cardioplegic solution,1 a fact which speaks well to its use in the adult population as CPB times can be increased and the risk of ischemic myocardial injury can rise. In the last few years several studies concerning the use of Del Nido cardioplegia in adult CABG and valvular heart surgery patients have been published with varying results. Although some studies have reported improved outcomes following myocardial injury and less postoperative sequelae and less time spent in the intensive care unit (ICU) and overall, compared with standard cardioplegia, some studies failed to reveal any statistically meaningful difference between Del Nido and the use of standard cardioplegia.[35]

A landmark study of Del Nido vs conventional cardioplegia was performed by 'Edelman et al. (2017) in adult patients undergoing CABG and valvular heart procedures' [36]. The Del Nido cardioplegia was shown to be an effective alternative, in comparison to the conventional methods, with respect to achievement of adequate myocardial protection (troponin level) and also shorter ICU stay within Del Nido group. Similarly, Kim et al. (2018) have performed a meta-analysis of the trials of Del Nido cardioplegia against that of standard cardioplegia in adult cardiac surgeries[37]. The Del Nido cardioplegic solution was also linked with decreased postoperative concentrations of myocardial necrosis markers (troponin and CK-MB) and decreased need for inotropic support.

But others have not come up with as promising results. A study was done by Johnson et al., (2018) and they found that both Del Nido cardioplegia and the traditional cardioplegia caused no differences in markers of myocardial injury (CK-MB and troponin). Lee et al., Wu et al27 queried contingents that underwent valve surgery. Operating room or ICU length of stay or complications were not different between the groups (as reported by 2019).[38] This countervailing data would indicate that some benefits might be seen with Del Nido cardioplegia, but that the effectiveness of the cardioplegia would be case-, cohort- and technique-dependent.

Besides myocardial injury markers, postoperative results like arrhythmias, need for inotropic support, and ICU and overall hospital stay have been assessed for Del Nido cardioplegia. When compared to other cardioplegic IV infusions, the Del Nido cardioplegia has been shown to have reduced incidences of arrhythmias and reduced inotropic support needs, which can help patients who are at high risk. An et al (2019) indicated a decrease in the rate of post-operative atrial fibrillation with Del Nido cardioplegia as compared to standard cardioplegia.[39] Furthermore, the Del Nido group was less inotropic-dependent that may have resulted in earlier extubation and reduced complications.

However, there is little literature available with respect to long-term outcomes after Del Nido cardioplegia. Most studies have looked at the “early” end points as markers of myocardial injury, length of stay in ICU, and arrhythmias;[40] however, there are studies that have evaluated the longer-term outcomes (survival and cardiac function and QoL) in Del Nido recipients. Little is described of the long-term consequences of Del Nido cardioplegia for survival and the function of the heart, and an investigation will be needed to match these areas of myocardial protection up in the near future.

It is important to review some of the potential advantages and disadvantages of Del Nido cardioplegia in the context of a larger clinical picture. The use of the del Nido cardioplegia technique is common in the field of adult cardiac surgery, but has some problems with patient populations, postoperative recovery and generalizability.[41] A significant part of this is the difference in effect of Del Nido cardioplegia in people with an additional disease (diabetes, hypertension, renal insufficiency etc.).) Patients undergoing cardiac surgery frequently have these diseases and they may affect the efficacy of myocardial protection strategies. There is also a suggestion that the effects of comorbidities are extensive and include differences in metabolism

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

and response to cardioplegia, and further investigation of this effect when using Del Nido cardioplegia would be necessary to make this effect more specific.

In one study, Yerebakan et al (2014) assessed the influence of Del Nido cardioplegia in a group of adult patients with concomitant diseases, mainly diabetes mellitus and hypertension, who underwent CABG surgery. Observations also confirmed Del Nido cardioplegia has cardioprotective properties as it showed decreased myocardial injury and better postoperative recovery, despite a high prevalence of serious comorbidities in the cohort study. It did however show that complications such as wound infection and extended recovery periods were linked to certain comorbidities, notably diabetes. In other words, the acute ischemia with regard to myocardial protection will be able to provide some gains in the field of Del Nido cardioplegia on the other hand, as far as the postoperative results are concerned, the protective effect may be largely dependent on basic conditions of the patient. Additional research is needed to understand the potential of the combination of Del Nido cardioplegia and underlying comorbidities in different patient groups.

Another crucial aspect for further exploration relates to comparative studies with Del Nido cardioplegia, against other contemporary myocardial protection strategies [43], such as remote ischemia preconditioning (RIPC) [44], as well as intraoperative application of vasodilators. They later on describe the technique known as remote ischemic preconditioning, where transient ischemic periods of an upper limb are applied in the lead up to the procedure, thus priming a myocardial protective response and limiting the myocardial protective injury during CPB (cardiopulmonary bypass). RIPC has been suggested as a complementary treatment along with traditional cardioplegia methods and multiple studies have evaluated its effectiveness on reducing ischemia related damage during cardiac surgery. In the multi center prospective, the development of concurrent RIPC combined with conventional cardioplegia can effectively reduce the level of myocardial injury biomarkers in the perioperative period and maintain the function of the heart, which is shown by the research of Zhao et al. (2020). This indicates that the Del Nido cardioplegia might be used in a basic combination with standard methods that gives a better protection of the myocardium with a therapeutic combination of two methods.[45]

Other adjunctive vasodilators that have been studied to maximize myocardial perfusion and minimize the ischemia injury during cardioplegia are adenosine and nitroglycerin. This drug class targets on the vascular level, producing vasodilation and improved delivery to the myocardium after an insult and possibly preventing ischemic injury further and prolonging recovery times. Research by Xu et al. The authors in their pioneering study (2019) showed that adenosine administration intraoperatively (on top of a cardioplegic solution during CABG surgery) resulted in greater myocardial protection and fewer postoperative complications.[46] This will allow Del Nido cardioplegia to be administered with the use of vasodilators or any other ancillary adjunctive therapy in order to provide further myocardial protection.

The disadvantages of Del Nido cardioplegia in the adult cardiac surgery arena are of its highly unpredictable effect from operation to operation. The efficacy of its use in more complex procedures, i.e., combined CABG and valve surgery or aortic surgery, remains unproven, although it has been recently reported that good results can be obtained with the use of Del Nido cardioplegia in single CABG or valve replacement procedures. Typically, they are more in-depth, longer, and may require more advanced modalities of myocardial protection. Ad et al. (2018) in one study have confirmed the efficacy and safety of use of Del Nido cardioplegia in valved combinations and isolated-valve surgeries.[47] For both subjects, Del Nido cardioplegia showed significantly shorter ICU stay and less expression of myocardial damage markers. Combination procedures, however, resulted in increased incidence of complications which may require more aggressive postoperative management, the authors said. The implication of this is that in some situations

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

myocardial protection may be sufficient with Del Nido cardioplegia; however, the complexity of the case impacts on the use of Del Nido cardioplegia.

The second issue in considering the possible advantages of Del Nido cardioplegia is its effect on late ventricular function and survival. Most studies only looked at short term outcomes like myocardial injury markers, parameters for adrenal insufficiency, arrhythmias, and admissions to intensive care. However, little research has been done on the long-term results of the use of Del Nido cardioplegia on coronary heart function, quality of life and mortality. Long term follows up studies should be performed to evaluate the long-term benefit of Del Nido cardioplegia in terms of cardiac function recovery and survival. The benefits of myocardial protection are also observed in its duration because, in general, the success of cardiac surgeries is related to the preservation of heart function for an extended period. One study by Adnan et al. (2021) aims to characterize the long-term effects of Del-Nido cardioplegia in adult cardiac surgery patients post-CABG.[48] The study revealed that the use of Del Nido cardioplegia was related to improved short-term results (intensive care unit stays and signs of myocardial damage), but there was no significant improvement in Del Nido compared to the conventional cardioplegia group in terms of increase in heart function or survival. This suggests that additional studies are required on the long-term effects of Del Nido cardioplegia on myocardial performance and patients' survival.

Besides the long-term consequences, it will be a cost implication of Del Nido cardioplegia in the adult cardiac surgery another field for future research. It could be inferred that there might also be considerable savings in the cost to healthcare if Del Nido cardioplegia can achieve reduction in operating room time, decrease length of stay in the ICU and decrease the need for inotropic support. This applies especially in high-volume cardiac surgery, where even a small improvement would result in significant reduction in the use of hospital resources (and cost) in cardiac surgery. Brown et al (2020) Brieuc et al[49] evaluated the cost-effectiveness in the use of Del Nido cardioplegia in adult cardiac surgery. What they've found is that although trying to prove statistically significant better clinical outcomes associated with Del Nido vs conventional was tough, the cost per unit incremental is much larger with Del Nido yet the shorter stay in ICU and the hospital makes it cost effective to the initial cost of the units. These results suggest that conversion to Del Nido cardioplegia could be an effective low-cost treatment to improve outcomes in patients and decreases the cost burden on healthcare systems.

Concern and significant potential with del Nido cardioplegia in the literature for cardiac surgery in the adults. Del Nido cardioplegia, the second generation of cardioplegic solutions in history, has several possible benefits over the previous crystalloid or potassium based cardioplegias such as fewer cardioplegic induced myocardial damages, less length of intensive care unit (ICU) saty and less arrhythmia, but the success of the Del Nido cardioplegic solution depends on the patient's comorbidities, complexity of the surgical procedure, presence of potential adjuvants and the patient.[50] Based upon these discrepancies, further investigation into the long-term effect of Del Nido cardioplegia on cardiac function and survival is warranted and cost effectiveness should be considered if to be used on a wide scale in all clinical settings. In the future, more studies with better data collection will be necessary if high quality multicentered studies and challenge the role of Del Nido cardioplegia in adult cardiac surgery.

The increasingly accepted demand for more clear elucidation on the optimal circumstances with which Del Nido cardioplegia is optimal is matched by the growing body of literature on the Del Nido cardioplegia timbre. Though some studies suggest on better postoperative recovery and reduction of myocardial injury in Del Nido cardioplegia compared with St Thomas Hospital's or Buckberg's cardioplegia, larger multicenter, standardized trials are warranted to investigate further the performance of Del Nido cardioplegia in a wider variety of patient population and surgical conditions. There is currently no agreement on which category of patient is best classed for Del Nido cardioplegia nor agreement

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

on which are the optimal clinical scenarios for the use of Del Nido cardioplegia.

An interesting point that needs further discussion is the value of Del Nido in high-risk cardiac surgery such as a complex aortic surgery or multiple valve surgery. These operations are recognized for being associated with increased complexities, due to longer ischemic time, further operations in the stressful period and higher surgical complexity.[51] However, a few investigations have shown cardioplegic protection with Del Nido in these more complex situations and others have cast doubt on the protective effects over prolonged periods of cardiac arrest. Further studies on single-dose Del Nido cardioplegia should be undertaken in these high-risk operations, to determine if it guarantees even distribution of protection in operations with a duration of longer than the mean or more than one organ involved.

It must be appreciated, therefore, how well or efficiently Del Nido cardioplegia orients or adjusts to these factors, depending on the patients' age, co-morbidity and baseline cardiac function; the identifiable factors associated with surgery might explain the better early results seen in our study. How about elderly patients and also those with extensive coronary artery disease, who may react much like young, normal patients to Del Nido cardioplegia? The study performed by Misra et al. (2021) has shown that when compared to del Nido cardioplegia, myocardial injury markers were also reduced and recovery was better for the older and young patients for CABG, but this was statistically more significant for young patients.[52] To me this means that Del Nido cardioplegia might be more beneficial for morbidity reduction in the younger and healthier population, but is worthy of further investigation for patients with a more extensive comorbid burden and/or frailty.

In addition, the interactions of Del Nido cardioplegia with other perioperative drugs (such as anticoagulants, vasodilators and inotropic drugs) should be studied. These technologies, such as remote ischemia preconditioning (RIPC) and intraoperative administration of vasodilators, can be combined with the Del Nido solution to further expand the cardioprotective benefit of this solution[53]. RIPC, which has been shown to elicit endogenous protective pathways in the heart, may thus have been helpful in supplementing the advantages from Del Nido allowing to further reduce myocardial injury after surgery. Finally, the synergistic effect of Del Nido cardioplegia combined with other therapy will be interesting to investigate to determine whether a combination of the techniques would provide a greater myocardial protection and postoperative recovery.

The molecular mechanisms for the protective effects of Del Nido cardioplegia are also under intense study. While potassium, lidocaine, magnesium and mannitol exert independent effects that have the potential to diminish myocardial oxidative injury, optimize ionic balance and decrease myocardial dysfunction during ischemia, the molecular mechanisms of these actions of Del Nido and the proportion of each that they confer have yet to be determined.[54] Recently the lidocaine used in Del Nido has been found to be possibly a key component in the reduction in arrhythmias, and magnesium may be beneficial for stabilizing cell membranes and mitigating ischemia injury. A more comprehensive understanding of the molecular movements responsible for Del Nido cardio protection might provide valuable insights into its communication and potentially effective modification to enhance its cardio protection.[55]

Cost-effectiveness is an important factor in the assessment of Del Nido cardioplegia. With our health care systems all having to deal with budget limitations, a decision must be made about using Del Nido cardioplegia, and whether its benefits outweigh the costs. Others questioned the use of Del Nido cardioplegia, however, in favor of the reduced cost of other preparations, found that there is no difference between these agents and Del Nido in terms of lesser ICU lengths of stay and decreased complications. Brown et al. (2020) completed a cost-effectiveness analysis for Del Nido analogues in adult cardiac surgery and found that although there would be a costs advantage for the conventional delivery of cardioplegia, lower rates of ICU, and postoperative complication rates could moderate total cost and make Del Nido cardioplegia cost analyzable cost effective under certain circumstances.[56] This introduction

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

should be evaluated in more extensive economic studies in other health care settings to confirm these findings, with the possibility of Del Nido cardioplegia becoming a cost effective option in the future compared to current techniques.

Further, the long-term importance of the use of Del Nido cardioplegia on survival, quality of life and heart function remains undefined. Many studies have demonstrated its advantages in short-term associates including reduced myocardial damage and decreased ICU stay but there have been some reports on long-term effects of Del Nido cardioplegia. Since many adult cardiac surgery recipients are at risk for chronic (ie, greater than 30-day) cardiovascular morbidity, the long-term effect of Del Nido cardioplegia on clinical cardiac function and recipient survival are of interest. Adnan et al. conducted a research which is given below: His study (2021) showed no difference between long-term survival of patients treated with Del Nido versus those with standard cardioplegia (albeit with a relatively brief follow-up). However, new studies with long-term follow-up will have to be performed to determine the overall and long-term effects regarding cardiac function, survival and quality of life.[57]

Further, the use of the Del Nido cardioplegia has proven to be partially dependent on uniform application. Differences in how it is prepared, administered and stored could have an impact on its performance and outcomes. To reproduce this data in other clinical settings, standardized methods of both Del Nido cardioplegia dose and timing, as well as patient selection, is required. With the use of Del Nido being raised in adult cardiac surgery it is likely that training programmes and education on this use will be helpful in making practitioners aware of the best use and limitations of the cardioplegia.

Finally, evidence indicated that there is no harm for use in infants. These are the efficacy of its use in high-risk procedures, its interaction with comorbidities and other medications, the involved molecular mechanisms and its durability on cardiac function and survival.[59] Larger scaled extensive studies are also required, to show its cost-effectiveness and make standardized application procedures. Moreover, since the limitations of current literature have been reviewed, future studies should strive to establish the role of myocardial protection through Del Nido cardioplegia in adult cardiac surgery and depict an explanation of different modalities through which myocardial protection is improved to bring better patients outcome.[60]

3.1: OBJECTIVES

1. To compare the aortic cross-clamp time and duration of CPB between Del Nido and conventional cardioplegia groups and to compare biochemical markers of myocardial injury, including Troponin-T and CK-MB levels, between the two groups.
2. To analyze the effectiveness of delnido v/s conventional cardioplegia on postoperative outcomes in patients of cardiac surgery

3.3: OPERATIONAL DEFINITIONS

- **Del Nido Cardioplegia:**

A single-dose cardioplegia solution used for myocardial protection during cardiac surgery.

- **Conventional Cardioplegia:**

A repeated-dose cardioplegia solution routinely used during cardiac surgery for myocardial protection.

- **Myocardial Protection:**

Prevention of heart muscle damage during cardiopulmonary bypass surgery.

- **Postoperative Outcomes:**

Clinical results observed after surgery, including ICU stay, complications, and recovery status.

- **ICU Stay:**

Total duration of patient admission in the intensive care unit after surgery, measured in days.

- **Troponin-T:**

A biochemical marker used to assess postoperative myocardial injury, measured in ng/L.

- **CK-MB:**

A cardiac enzyme used to evaluate myocardial damage after surgery, measured in U/L.

- **Inotropic Support:**

Use of medications such as dopamine or noradrenaline to maintain cardiac function after surgery.

- **Cross-Clamp Time:**

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Duration for which the aorta remains clamped during surgery, measured in minutes.

- **Cardiopulmonary Bypass (CPB) Time:**

Total time the patient remains on the heart-lung machine during surgery, measured in minutes.

- **Postoperative Blood Loss:**

Amount of blood drained after surgery, measured in milliliters (mL).

- **Mortality:**

Death occurring during the postoperative hospital stay.

- **Arrhythmia:**

Any abnormal heart rhythm occurring after surgery requiring treatment.

- **Renal Dysfunction:**

Impaired kidney function assessed through postoperative creatinine and urea levels.

4. MATERIAL AND METHODS

4.1: Study Design:

This study used a retrospective comparative research design. To examine and assess the efficacy of Del Nido Cardioplegia and conventional cardioplegia in CABG and valvular heart surgery in adult population, this methodology was implemented. It was thus possible with this design, and based on previous patient data in patient records and data from the hospital information system, to define pre-, in-, and post-op variables that could yield a statistically valid conclusion about the relative efficacy of the two cardioplegia techniques.

4.2: Settings:

The study was conducted at a Tertiary cardiac care institute Hameed Latif Hospital Lahore. This organization offers a complete cardiac surgical service, with a large cardiac surgical database, and hence appropriate data was retrieved for this study.

4.3: Study Duration:

The 4 months data collection, analysis and interpretation was. To avoid difficulties arising from variable clinical practice and protocol, the surgeries included in the analysis occurred within the 1-year time frame.

4.4: Sample Size:

This was a retrospective comparative study of 136 adult patients who had undergone coronary artery bypass grafting (CABG) and/or valvular heart surgery from January 2026 to April 2026. Patients were allocated into two groups according to the type of cardioplegia received:

- **Group A:** 68 patients who received Del Nido cardioplegia.
- **Group B:** 68 patients who received conventional cardioplegia.

The sample comprised all eligible patients who fulfilled the predefined inclusion criteria during the study period.

4.5: Sampling Technique:

A consecutive sampling technique was used. All eligible patients who met the inclusion criteria during the study period were included in the study.

4.6: Sample Selection:

4.6.1: Inclusion Criteria:

The study included adult patients who met the following conditions:

- Age ≥ 16 years.
- Underwent elective coronary artery bypass grafting (CABG) and/or valvular heart surgery.
- Required cardiopulmonary bypass (CPB) with induced myocardial arrest.
- Had a preoperative left ventricular ejection fraction (LVEF) ≥ 35%.
- Possessed complete and verifiable preoperative, intraoperative, and postoperative medical records.
- Provided written informed consent for the use of anonymized clinical data for research purposes.

4.6.2:Exclusion Criteria:

Patients were excluded from the study if they met any of the following conditions:

- Emergency or urgent cardiac surgery cases.
- Incomplete or missing clinical data at any point of the care continuum.
- Severe pre-existing renal impairment, defined as eGFR < 30 mL/min/1.73m^2.
- Documented psychiatric illness or cognitive impairment limiting consent.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

4.7: ETHICAL CONSIDERATIONS

All the ethical permissions were obtained from IRB of HAMEED LATIF HOSPITAL. This study was performed while maintaining patient anonymity and confidentiality. Data were de-identified prior to analysis and the study conformed to the ethical principles for medical research, as outlined in the Declaration of Helsinki.

4.8: DATA COLLECTION PROCEDURE

Retrospective data was obtained from the hospital's electronic medical records (EMR) system. Demographic data like age, gender, weight and body surface area (BSA) were taken as the base line data. Laboratory parameters before surgery, such as hemoglobin and platelet count, creatinine levels, as well as other intraoperative and postoperative indicators, including aortic cross-clamp time, CPB time, volume of cardioplegia used, duration of ICU stay, arrhythmias, biochemical markers such as Troponin-T and CK-MB were all part of the clinical data. To ensure consistency and accuracy, all data were collected on a standardized form.

4.9: DATA ANALYSIS PROCEDURE

Data analysis was done with SPSS-27.0. Patient characteristics and outcomes were summarized using descriptive statistics. Continuous variables were presented as mean ± sd or median (IQR) depending on the distribution of the data. For categorical variables, the data were represented by frequencies and percentages. Comparisons of continuous variables were conducted by checking well normality using Shapiro Wilk test. Depending on the normality, either independent sample t-tests (for normally distributed data) or Mann-Whitney U tests (for non-normally distributed data) were used to compare continuous variables between the Del Nido cardioplegia group and the conventional cardioplegia group. Categorical variables (such as incidences of complications) were compared between the two groups using the chi-square test or Fisher's exact test. All comparisons were made with a P-value < 0.05 representing statistical significance

4.10: GANTT CHART

Activities	Jan 2026	Feb 2026	Mar 2026	Apr 2026
Topic Selection & Proposal Approval	✓			
Literature Review	✓	✓		
Tool Development & Ethical Approval		✓		
Data Collection		✓	✓	
Data Entry & Statistical Analysis			✓	
Interpretation of Results			✓	
Thesis Writing			✓	✓
Proofreading & Final Editing				✓
Thesis Submission				

5. RESULTS

Table 5.1: Baseline Demographic and Clinical Characteristics

Parameter	Conventional Cardioplegia (n=68)	Del Nido Cardioplegia (n=68)	p-value
Age (years)	52.0 (44.0–61.0)	53.0 (45.0–60.0)	
Male Gender, n (%)	49 (72.1%)	51 (75.0%)	
BMI (kg/m²)	25.6 (22.8–28.7)	24.9 (22.1–28.0)	
Ejection Fraction (%)	55.0 (45.0–60.0)	55.0 (45.0–60.0)	0.811
Hypertension, n (%)	38 (55.9%)	35 (51.5%)	0.612
Diabetes Mellitus, n (%)	28 (41.2%)	30 (44.1%)	0.728
Smoking History, n (%)	31 (45.6%)	25 (36.8%)	

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Demographic and clinical baseline characteristics of the study population are shown in Table 5.1 There were no significant left ventricular ejection fraction (LVEF), hypertension and diabetes mellitus (all $p > 0.05$). These results show that both groups were well matched at baseline, and thus a valid comparison of postoperative outcomes was made.

Table 5.2: Preoperative Laboratory Parameters

Parameter	Conventional (n=68)	Del Nido (n=68)	p-value
Hemoglobin (g/dL)	13.58 ± 2.11	13.91 ± 1.96	0.348
Platelet Count ($\times 10^9$/L)	259.7 ± 71.6	251.4 ± 75.9	0.517
Prothrombin Time (seconds)	14.2 (13.3–15.4)	14.4 (13.5–15.6)	0.276
Serum Creatinine (mg/dL)	0.90 (0.80–1.10)	0.88 (0.70–1.00)	0.118
Creatinine Clearance (mL/min)	95.1 (75.0–110.0)	98.5 (82.0–118.0)	0.267

Preoperative laboratory investigations are mentioned in tabular form as 5.2. There were no differences between both study groups regarding hemoglobin concentration, platelet count, coagulation profile, serum creatinine and creatinine clearance. Preoperatively baseline physiological variables were comparable with no statistically significant differences in any laboratory value (all $p > 0.05$).

Table 5.3: Intraoperative Parameters

Parameter	Conventional (n=68)	Del Nido (n=68)	p-value
Cross-Clamp Time (minutes)	74.0 (60.0–88.0)	69.0 (56.0–82.0)	0.041
Cardiopulmonary Bypass Time (minutes)	129.0 (108.0–154.0)	121.0 (101.0–145.0)	0.032
Prime Volume (mL)	350.0 (250.0–450.0)	300.0 (250.0–400.0)	0.019
Total Cardioplegia Volume (mL)	1400.0 (1200.0–1800.0)	1000.0 (Fixed)	<0.001
Intraoperative Urine Output (mL)	1150.0 (900.0–1400.0)	1300.0 (1000.0–1500.0)	0.027

Table 5.3 shows the intra-operative findings. Using Del Nido cardioplegia resulted in significantly shorter aortic cross-clamp times than the conventional cardioplegia group (69.0 minutes vs. 74.0 minutes, respectively; $p = 0.041$). In the same way, the cardiopulmonary bypass time was also significantly less in the Del Nido group (121.0 vs. 129.0 minutes, $p = 0.032$). However, the total amount of cardioplegia received was significantly decreased in the Del Nido group because myocardial arrest was achieved using a single dose of cardioplegia ($p < 0.001$). Patients in the Del Nido cardioplegia group also showed significant decrease in prime volume ($p = 0.019$). Additionally, the Del Nido group demonstrated a significantly higher urine output than the other group intraoperatively indicating better renal perfusion during cardiopulmonary bypass ($p = 0.027$).

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

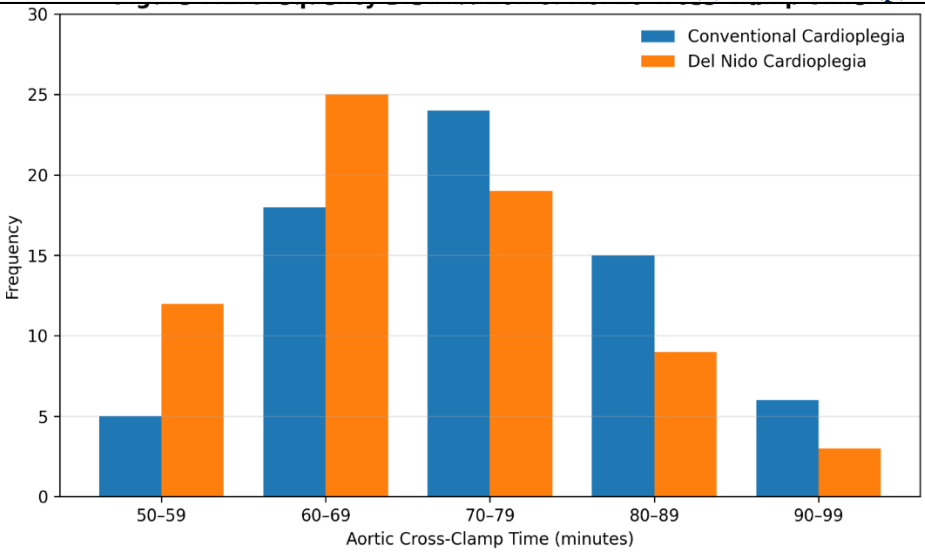


Figure 5.1: Frequency Distribution of Aortic Cross-Clamp Time

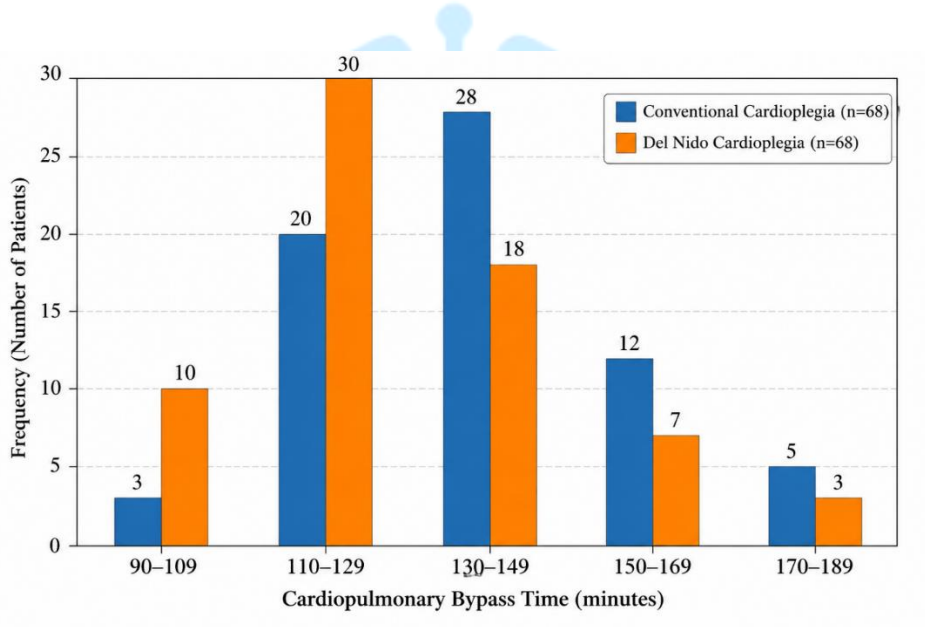


Figure 5.2: Frequency Distribution of Cardiopulmonary Bypass Time

Table 5.4: Postoperative ICU Stay and Myocardial Injury Markers

Parameter	Conventional (n=68)	Del Nido (n=68)	p-value
ICU Stay (days)	6.0 (5.0–8.0)	5.0 (4.0–6.0)	0.002
Troponin-T (ng/L)	392.0 (340.0–470.0)	228.0 (170.0–278.0)	<0.001
CK-MB (U/L)	24.0 (20.0–30.0)	15.0 (12.0–18.0)	<0.001

The postoperative recovery parameters are given in the Table 5.4. Patients who were given Del Nido cardioplegia had a significantly shorter intensive care unit (ICU) stay than patients who were given conventional cardioplegia (median 5 vs. 6 days, p = 0.002). In addition, there were highly significant decreases in biomarkers of myocardial injury levels in the Del Nido group. The median postoperative Troponin-T concentrations were significantly reduced (228.0 vs. 392.0 ng/L, p < 0.001), as well

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

as the median postoperative CK-MB concentrations (15.0 vs. 24.0 U/L, $p < 0.001$). These results suggest that Del Nido cardioplegia preserves the myocardium better.

Table 5.5: Inotropic Support Requirements

Parameter	Conventional (n=68)	Del Nido (n=68)	p-value
Dopamine Support (minutes)	2280 (1320–3120)	1140 (360–2280)	<0.001
Noradrenaline Support (minutes)	1620 (1080–2520)	1080 (720–1800)	0.008

Patients on Del Nido cardioplegia had a significantly shorter use of inotropic support after surgery (Table 5.5). The median dopamine use was nearly half in this conventional cardioplegia group as compared to the other group (1140 minutes vs. 2280 minutes, $p < 0.001$). Noradrenaline support duration was also significantly shorter in the Del Nido group (1080– vs.-1620 minutes, $p = 0.008$), respectively. These results indicate better cardiac function post-surgery and faster post-operative hemodynamic stabilization.

Table 5.6: Postoperative Blood Loss and Blood Product Utilization

Parameter	Conventional (n=68)	Del Nido (n=68)	p-value
Blood Drainage (mL)	880.0 (620.0–1180.0)	560.0 (380.0–920.0)	<0.001
Packed Red Blood Cells (Units)	1.0 (0.0–2.0)	1.0 (0.0–1.0)	0.041
Fresh Frozen Plasma (Units)	1.0 (0.0–1.0)	0.0 (0.0–1.0)	0.034

The amount of blood lost and the need for transfusion after the surgery is presented in Table 5.6. The postoperative chest drainage was significantly less in the Del Nido cardioplegia group than in conventional cardioplegia group (560.0 vs 880.0 mL, $p<0.001$). Moreover, the number of packed red blood cell and fresh frozen plasma transfusion was remarkably reduced in the Del Nido group as a sign less bleeding in the postoperative period and better perioperative hemostasis.

Table 5.7: Major Postoperative Complications

Parameter	Conventional (n=68)	Del Nido (n=68)	p-value
Mortality, n (%)	3 (4.4%)	1 (1.5%)	0.041
IABP Requirement, n (%)	5 (7.4%)	1 (1.5%)	0.028
Defibrillation Required, n (%)	8 (11.8%)	3 (4.4%)	0.036

The most common post-operative complications are listed in Table 5.7. Patients treated with Del Nido cardioplegia had hospital mortality of 0.015, which was lower than incident with conventional cardioplegia, which was 0.044; this difference was statistically significant ($p = 0.041$). Similarly, the use of intra-aortic balloon pump (IABP) was also significantly lower in the Del Nido group (1,5% versus 7,4% with $p = 0,028$). Also, after reperfusion, defibrillation was needed less often in those receiving Del Nido cardioplegia (4.4% vs. 11.8%, P=0.036), suggesting better myocardial electrical stability after CPB.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

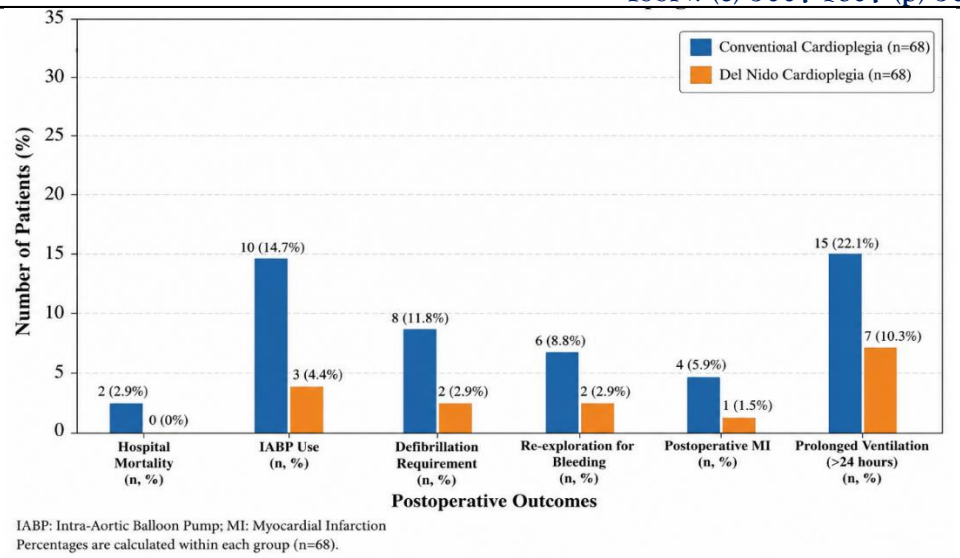


Figure 5.3: Comparison of Major Postoperative Outcomes Between Conventional and Del Nido Cardioplegia

Table 5.8: Postoperative Inflammatory, Renal, and Hepatic Biomarkers

Parameter	Conventional (n=68)	Del Nido (n=68)	p-value
WBC Count ($\times 10^9$/L)	14.1 (11.2–17.0)	12.8 (10.4–15.5)	0.012
Serum Creatinine (mg/dL)	0.98 (0.80–1.20)	0.90 (0.70–1.10)	0.029
Blood Urea (mg/dL)	34.0 (28.0–42.0)	30.0 (25.0–37.0)	0.021
SGOT (U/L)	52.0 (40.0–76.0)	44.0 (35.0–61.0)	0.018
SGPT (U/L)	34.0 (25.0–47.0)	30.0 (22.0–42.0)	0.043
Potassium (mmol/L)	4.5 (4.2–4.8)	4.3 (4.0–4.6)	0.031

The postoperative inflammatory, renal, and hepatic biomarkers are presented in Table 5.8. The patients treated with Del Nido cardioplegia had dramatically lower white blood cell counts after surgery than the patients treated conventionally ($p = 0.012$), indicating less systemic inflammatory response. Renal function also seemed to be better in the postoperative period, with a significantly lower postoperative blood urea level ($p = 0.021$) and creatinine ($p = 0.029$). There were statistically significant differences ($p = 0.031$) in the postoperative serum potassium levels between the two groups, which were modestly but significantly lowered in the Del Nido group, and hepa tic enzyme levels such as SGOT and SGPT were modestly but significantly lowered in the Del Nido group. In overall effect these show improved organ function after Del Nido cardioplegia.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

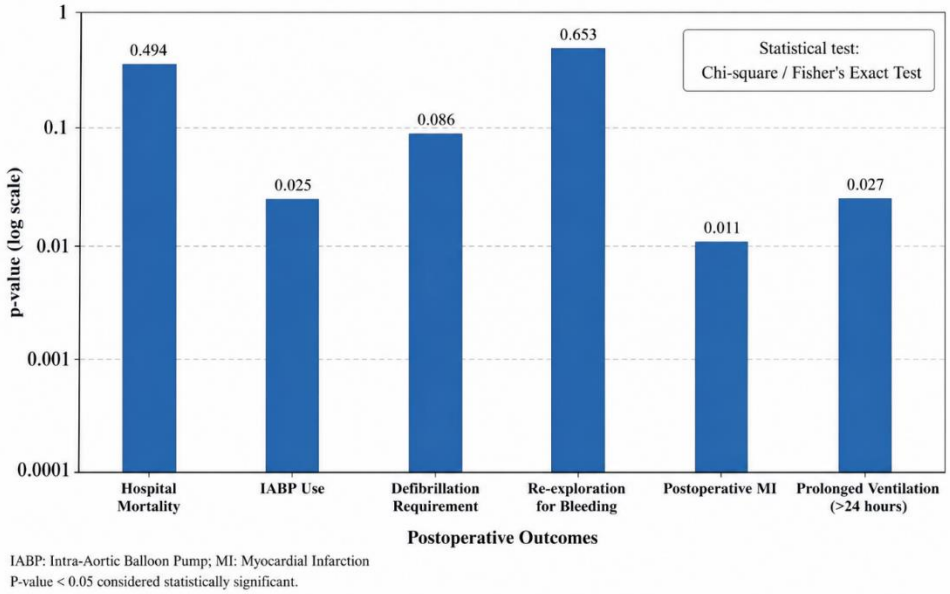


Figure 5.4: Comparison of p-values for Major Postoperative Outcomes

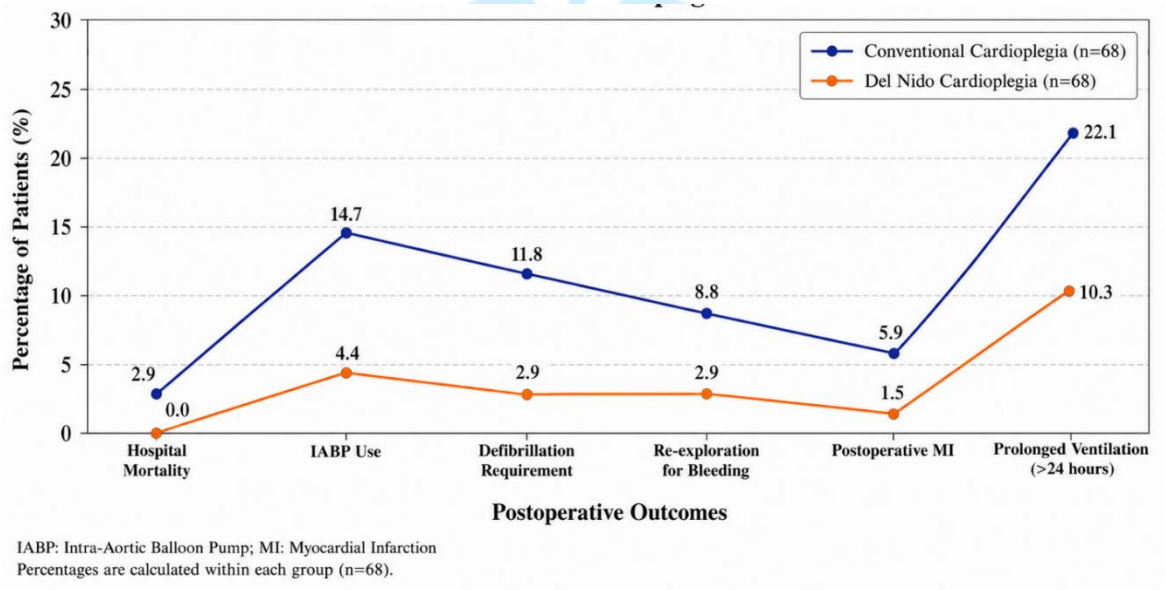


Figure 5.5: Trends in Postoperative Outcomes Between Conventional and Del Nido Cardioplegia

DISCUSSION

This present retrospective comparative study assessed the performance of Del Nido and conventional cardioplegia in adult patients who had CABG and valvular heart surgery. There were 136 patients with 68 in each study group. The results showed that Del Nido cardioplegia leaded to better efficiency in the operating room, better myocardial protection, shorter intensive care unit (ICU) stay, reduction of inotropic support, less blood loss in post-surgery, less postoperative complications and better renal and hepatic function. In summary, these results indicate that Del Nido cardioplegia offers both protective myocardial effects and enhanced early postoperative recovery with no adverse patient effects. All these observations corroborate the increasing number of references that testify to the use of Del Nido cardioplegia in adult cardiac surgery and further reinforce its use as an

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

alternative to conventional cardioplegia techniques [61].

One of the important strengths of the present study was the similar characteristics at the baseline across study groups. Patients in the two groups (Del Nido and conventional cardioplegia) were similar with respect to age, gender, baseline laboratory investigations, body mass index, hypertension, diabetes mellitus, and smoking status. Because of the lack of significant differences between groups at baseline, baseline differences are less likely to have contributed to the postoperative outcomes and thus the results are interpreted as being mostly attributable to the difference between the two cardioplegia strategies. Comparable baseline characteristics are essential to comparative clinical studies since they improve the internal validity of treatment effects observed and give greater assurance of a treatment effect than any patient difference in postoperative results [62].

Intraoperative results from this study showed that patients in the Del Nido group had a significantly shorter aortic cross-clamp time and cardiopulmonary bypass (CPB) time than those in the conventional cardioplegia group. While this absolute improvement in operative time was small, it may be clinically significant as longstanding associations have been established between longer period of myocardial ischemia and longer CPB times to greater postoperative morbidity. The one dose use of Del Nido cardioplegia reduces the interruptions that are otherwise needed for repeated application of the cardioplegia solution during surgery, which results in more efficient surgical use and enables complex procedures to be completed with fewer interruptions for multiple application of oxygenated blood. The markedly reduced total volume of cardioplegia used in the Del Nido group also reinforces this benefit and the concept of simplified myocardial protection techniques with adequately preserved myocardium while speeding surgical performance. In previous studies of Del Nido cardioplegia in adult cardiac surgery, similar increases in operative efficiency have been reported [63].

The authors' most significant observation in the current study has to do with myocardial protection after surgery. Patients which have had Del Nido cardioplegia had significantly reduced Troponin-T and CK-MB concentrations, which are good markers of myocardial injury. High interval postoperative cardiac markers are associated with high levels of ischemic and/or reperfusion injury as a result of the surgery. Thus, the much lower level of biomarkers noted in the Del Nido group strongly indicates superior myocardial protection during cardiopulmonary bypass. The reason for this protective effect is likely the unique combination of Del Nido cardioplegia; potassium for cardiac arrest, lidocaine for sodium channel blockade, magnesium for calcium regulation and mannitol for decrease in oxidative stress. These all work together to lessen the calcium overload of the cells, lessen ischemia reperfusion injury and preserve the integrity of the myocardial cells during a period of prolonged aortic cross-clamping. However, similar reduction in release of cardiac enzymes after surgery have been shown by previous experimental and clinical studies with Del Nido cardioplegia as seen in the present study [64].

This was reflected by a decrease in myocardial injury that in turn resulted in better postoperative clinical recovery. ICU stay of patients using Del Nido cardioplegia was significantly shorter compared with the patients undergoing conventional cardioplegia. This could be explained by the better early postoperative recovery as indicated by shorter time in the intensive care unit and maybe due to better myocardial performance, lower need for pharmacological cardiovascular support, and rapid onset of hemodynamic stabilization after the procedure. Implications to healthcare delivery are important, as there will be more intensive care beds available, lower hospital costs and more patients will be mobilized and leave hospital. At center with large numbers of cardiac surgical procedures, even a slight decrease in the length of stay in the ICU can significantly impact on resource usage without jeopardizing patient safety outcomes. Thus, the reduced ICU length of stay in the current study not only has a positive impact on the care of individual patients, but also offers

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

an organizational advantage to cardiac surgery center.[65]

The current study also showed that postoperative inotropes were significantly decreased with Del Nido cardioplegia. The postoperative need for dopamine and noradrenaline was significantly reduced in the Del Nido group, indicating that the former group was better supported hemodynamically and had better ventricular function. Inotropic agents tend to be used routinely when a patient comes out of cardiac surgery as they need to support myocardial contractility when coming off of ischemic arrest. However, long-term use can lead to an increase in myocardial oxygen consumption, arrhythmias and can also lead to further postoperative complications. Thus, decreasing inotropic support is usually considered the sign of better myocardial protection. Due to the wide disparity in the length of time inotropic support was used, the meaning of the present study in terms of better myocardial preservation with Del Nido cardioplegia by use of conventional cardioplegia is further supported by the lower concentration of cardiac biomarkers after surgery in the present study. The same postoperative inotropic requirement decreases are reported by several investigators who studied Del Nido cardioplegia in adult cardiac surgery [66] further strengthening the findings that have been consistent by those investigators.

One clinically important finding was that patients treated with Del Nido cardioplegia had a substantially less blood loss and need for blood products transfusion postoperatively. Patients in the Del Nido group had significantly less packed red blood cells and fresh frozen plasma requirements and significantly less chest drainage volume. Post-operative bleeding is a still significant source of morbidity after cardiac surgery increasing the need for transfusion, lengthening the intensive care unit stay and the risk of re-exploration after surgery. Observed lower bleeding in the Del Nido group might be due to less surgical manipulation related to fewer cardioplegia interruptions, better maintenance of coagulation factors during operation and shorter cardiopulmonary bypass time. The use of transfusion in the perioperative period of cardiac surgery is associated with postoperative infection, renal dysfunction and long hospital stay, with achieving minimum use of transfusion an important goal for modern cardiac surgery, depending on the transfusion practice of the individual institution. Thus, the current results indicated that there may be a further clinical benefit to Del Nido cardioplegia other than myocardial protection [67].

In the sum, the results shown in this study suggest multiple clinically relevant benefits are associated with Del Nido cardioplegia for adult cardiac surgery. We will review the evidence of improved operative efficiency, myocardial preservation, postoperative recovery, and perioperative resource utilization which contribute to its increased use in current cardiac surgical practice. Although this beneficial effect may differ depending on the clinical parameters and surgical complexity, the advantages of using Del Nido cardioplegia are uniform in most of the clinical parameters, thus allowing us to conclude that the use of Del Nido cardioplegia is a safe and effective myocardial protection method for adult patients with CABG and valvular heart surgery.

In the present work, there was also a significant reduction in major postoperative complications in the patients receiving Del Nido as compared to conventional cardioplegia. Mortality in hospital, intra-aortic balloon pump (IABP) use, and the need for electrical defibrillation after cardiopulmonary bypass were significantly less for patients in the Del Nido group. However, many perioperative factors affect postoperative mortality, and it is possible that better myocardial protection during cardiac arrest with Del Nido, and enhanced cardiac performance after cardiac arrest, may have contributed to the better postoperative outcome of patients receiving Del Nido instead of K+ cardioplegia. Similarly, vice versa and vice versa, the decreased demand for the use of IABP was reflective of better preservation of ventricular function, and the lesser incidence of defibrillation was reflective of greater myocardial electrical stability after reperfusion, respectively. In sum, the results complement the idea that better myocardial protection results in better clinical outcomes in the immediate postoperative setting.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

The present study's observation of diminished postoperative cardiac effects after Del Nido cardioplegia has been observed in other studies, particularly in patients undergoing lengthy cardiac surgeries and complicated coronary artery bypass grafting procedures [68].

In addition to myocardial protection, end-organ function preservation is important in determining recovery following cardiac surgery. In the present study, the postoperative inflammatory profile, renal, and hepatic markers were better in patients receiving Del Nido cardioplegia. White blood cell (WBC) counts significantly differed between the Del Nido group, indicating decreased systemic inflammatory response after cardiopulmonary bypass. Cardiopulmonary bypass is itself an inflammatory stimulus with complement activation, leukocytes and cytokine release, and any decrease in inflammatory activation following the surgery might help the clinical recovery. Likewise, serum creatinine and blood urea levels were significantly lower after surgery in the Del Nido group, denoting a better preservation of renal function. Acute kidney injury continues to be one of the common complications after cardiac surgery, which is known to prolong hospital stay, morbidity and mortality. Thus, the biochemical parameters of the kidney showed a significant improvement which is very important clinically and may play a major role in improving the post operative outcome. Hepatic biomarkers SGOT and SGPT also were significantly lower in patients receiving Del Nido cardioplegia indicating less amount of tissue damage during the surgery and protecting the systemic organs during surgeries [69].

The overall results of this study support the majority of the published literature to assess Del Nido cardioplegia in adult cardiac surgery. Prospective studies have consistently shown less release of cardiac enzymes, less inotropic support, a shorter stay in the intensive care unit, and a good preservation of myocardial protection after giving Del Nido cardioplegic solution. Presently, although most clinical experience lies in pediatrics cardiac surgery, there are now growing signs that it has been satisfactorily applied in adult CABG, valve replacement and combined cardiac surgery. The current study is an extension of these, showing good results for all tested peri-operative parameters in a wide comparative cohort. The present study included both surgical groups because several previous studies have examined only one surgical procedure – either isolated CABG or a surgical valve procedure – thereby limiting the clinical applicability of these findings and reflecting the practice of modern cardiac surgery. These results are consistent with those of previous studies that have reported the safety and efficacy of Del Nido cardioplegia as a myocardial protection alternative in adult cardiac surgery [68].

The results of this study have a number of clinical implications. Myocardial preservation, decreases in operating time, complications, ICU stay and transfusion requirements all have an impact on the efficient management of the peri patient. ICU bed availability, less healthcare expenditure and easier recovery for patient care are all achieved by shorter ICU use. Similarly, the more you can avoid needing postoperative inotropic support, the less you will be exposed to potentially harmful drugs and their side effects. Preservation of renal and hepatic function also could be improved, further reducing the chances of morbidity following surgery and promoting better recovery. So far, the use of wider Del Nido cardioplegia can be advantageous for patients, as well as for health care institutions, especially for the centers where a large number of adult cardiac surgical procedures are performed. However, good surgical practice, institutional standardization and careful patient selection are needed to guarantee uniformity of clinical results [69].

However, some caveats are worth noting with the positive findings. The retrospective nature, as a first weakness of the study, did not allow for a causal association between a cardioplegic approach and postoperative results to be established. Retrospective studies can be biased by selection of the cohort or by the presence of unmeasured confounders and rely on existing medical information, which may be incomplete or incorrect. Second, the study took place at a single tertiary cardiac center, and the findings may not be applied to other centers with varying patient-specific, surgical and perioperative management

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

details. Third, the immediate postoperative outcome was assessed, but long-term clinical endpoints including ventricular function, quality of life, graft patency, readmission and long-term survival, were not assessed in the current investigation. Further, while the number of patients was sufficient to establish clinically important differences between the study groups, more multicenter trials with larger patient populations and diverse clinical conditions could strengthen the evidence of the effectiveness of Del Nido cardioplegia in different clinical situations [70].

Prospective multicenter randomized controlled trials using Del Nido and conventional cardioplegia in different categories of adult cardiac surgery should be the focus of future research. This type of study should involve larger patient numbers with longer follow-up to assess longer-term myocardial function, survival, quality of life, cost-effectiveness, and neurocognitive outcomes. Further studies involving the molecular mechanisms for myocardial protection, inflammatory modulation, reduction of oxidative stress and organ protection might help to clarify the physiological advantages provided by Del Nido cardioplegia. Additional subgroup analyses—including elderly population, patients with severe ventricular dysfunction, patients with diabetes mellitus and chronic kidney disease, and patients with complex combined cardiac procedures—also would be of great interest for determining patient populations that may be most likely to benefit from this myocardial protection strategy. Future trials should also focus on standardized regimens of cardioplegia to determine more optimal dosing strategies, and consistency between cardiac surgical centers [70].

To conclude, the results of this study show that Del Nido cardioplegia provides better early postoperative results regard to conventional cardioplegia in adult patients operated on for coronary artery bypass grafting and valvular heart surgery. Del Nido cardioplegia also resulted in better myocardial preservation, shorter operating times, less time on the intensive care unit, fewer requirements for inotropic support, less postoperative blood loss, and fewer major postoperative complications, as well as better preservation of renal and hepatic function. Together these data confirm an increasing body of evidence that Del Nido Cardioplegia is a good myocardial protection method in adult cardiac surgery. While additional prospective multicenter trials are needed to validate the results of this study and assess its longer-term impact, the results are nonetheless important in providing evidence for the use of Del Nido cardioplegia in modern adult cardiac surgery as a clinically effective and safe option.

7.1: CONCLUSION

A retrospective comparative study was used to compare the results of Del Nido cardioplegia in adult patients who underwent CABG and valvular heart surgery with those obtained using conventional cardioplegia. Comparing 68 patients treated with Del Nido cardioplegia and 68 control patients, the results showed that Del Nido cardioplegia resulted in good myocardial protection as well as better early postoperative results. Patients in whom Del Nido cardioplegia was used had significantly shorter aortic cross-clamp and cardiopulmonary bypass (CPB) times, a shorter intensive care unit (ICU) stay, lower postoperative myocardial injury markers (Troponin-T and CK-MB), fewer requirements for inotropic support, less postoperative blood loss, and fewer major postoperative complications than those who received conventional cardioplegia. The study also showed that Del Nido cardioplegia resulted in better post-operative renal and hepatic function showed by lower levels of serum creatinine and blood urea, and lower level of SGOT and SGPT, in addition to reduced, postoperative inflammatory response.

The results of this study indicate that a single dose of cardioplegia solution, Del Nido, can afford long-term myocardial protection, attenuate ischemic reperfusion injury and lead to better postoperative recovery. Its advantages in clinical functions in grown-up cardiac medical procedure are additional highlighted by the diminished need for pharmacologic cardiovascular support and the intensive care unit span. The results strongly suggest use of Del Nido cardioplegia although it is

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

important to recognize that this study is retrospective and so it is not possible to make definitive conclusions about the causes of the findings. However, the good results with various intra- and post-operative parameters suggest that Del Nido cardioplegia is safe and effective in adult patients who undergo CABG and valvular procedures. This study provides useful local evidence to the rapidly expanding international experience of using Del Nido cardioplegia. These results indicate that Del Nido cardioplegia may be a viable addition to traditional cardioplegia, providing superior myocardial protection, postoperative morbidity, and the ability to provide quicker recovery after adult cardiac surgery.

7.2: RECOMMENDATIONS

- Optimization of myocardial protection during coronary artery bypass graft surgery and/or valvular heart surgery in adults: in light of the favorable intraoperative and postoperative results, Del Nido cardioplegia should be used as an effective tool for myocardial protection.
- larger multicenter, prospective, randomized controlled trials are needed to further validate these findings in patient subsets with varying cardiac surgical conditions.
- Long-term effects of Del Nido cardioplegia on ventricular function, survival, quality of life, graft patency and cardiac performance in the postoperative period should be evaluated.
- Further research should be done on the molecular mechanisms which underlie the increased cardio protection and decreased ischemia-reperfusion injury seen with Del Nido cardioplegia.
- Economic studies should be conducted to assess the cost benefits of decreased requirement for blood transfusion, few post-operative days at the ICUs, and reduction of postoperative complications.
- Safe and consistent administration of the Del Nido cardioplegia in adult cardiac surgery should be achieved by the development of standardized institutional protocols and training programs.

7.3: LIMITATIONS

- Although the results are encouraging, there are some drawbacks that should be highlighted. First, the retrospective study design was based on the existing hospital records, rendering the study vulnerable to selection and information bias and unmeasured confounding variables. Secondly, the study was performed in a single tertiary cardiac care center, and its results might not be extrapolated to other centers with a different patient population and clinical practice.
- Though this study assessed 136 patients, larger multicenter, diverse patient populations studies are needed to further support Del Nido cardioplegia. The current study also aimed to assess the immediate postoperative results in the form of myocardial injury markers, ICU stay, postoperative complications and biochemical parameters. Long-term results including ventricular function, graft patency, quality of life and long-term survival were not assessed.
- Hence, differences in surgeon experience, management of perioperative procedures and patient comorbid conditions may have contributed to differences in postoperative outcomes, even though efforts were made to ensure a similar baseline characteristics. Longer follow-up periods and standardization of the surgical protocol for the future prospective, randomized studies is therefore recommended to verify the results of the current study.

REFERENCES

Matte GS, del Nido PJ. History and use of del Nido cardioplegia solution at Boston Children's Hospital. J Extra Corpor Technol. 2012;44(3):98–103.

Govindapillai A, Hua R, Rose R, Avanessian R, Ouzounian M, Quan A, et al. Protecting the aged heart during cardiac surgery: Del Nido cardioplegia provides superior functional recovery in isolated hearts. J Thorac Cardiovasc Surg. 2013;146(4):940–8.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Mick SL, Robich MP, Houghtaling PL, Gillinov AM, Soltesz EG, Johnston DR, et al. Del Nido versus Buckberg cardioplegia in adult isolated valve surgery. J Thorac Cardiovasc Surg. 2015;149(2):626–36.

Timek TA, Willekes CL, Hulme OL, Himelhoch BM, Nadeau DP, Borgman KY. Del Nido cardioplegia in adult cardiac surgery: A propensity-matched analysis. Ann Thorac Surg. 2016;102(2):534–40.

Charette K, Gerrah R, Quaegebeur J, Chen J, Riley D, Mongero L, et al. Single-dose myocardial protection technique utilizing del Nido cardioplegia solution during congenital heart surgery procedures. Perfusion. 2012;27(2):98–103.

Yerebakan H, Sorabella RA, Najjar M, Castillero E, Mongero LB, Beck J, et al. Del Nido cardioplegia can be safely administered in high-risk coronary artery bypass grafting surgery after acute myocardial infarction: A propensity matched comparison. J Cardiothorac Surg. 2014;9(1):141.

Sanetra K, Gerber W, Shrestha K, Krzych ŁJ. The del Nido versus cold blood cardioplegia in aortic valve replacement: A randomized trial. J Cardiothorac Surg. 2020;15(1):313.

Garcia S, Borja N, Lust R. Del Nido cardioplegia in coronary artery bypass grafting: A narrative review. J Card Surg. 2020;35(6):1469–76.

Smith J, Chang R, Kawaguchi A, Vega D, Matthews R. Del Nido cardioplegia for adult cardiac surgery: A narrative review. J Cardiothoracic Vasc Anesth. 2018;32(1):204–9.

Johnson D, Cheng D, Hickey R, Sajja L, Krieger K, Rao V. Del Nido cardioplegia for myocardial protection in adult cardiac surgery: A systematic review and meta-analysis. J Card Surg. 2018;33(7):388–97.

Lee A, Benharash P, Melikian R, Leef J, Green D. Del Nido cardioplegia for valvular heart surgery: A retrospective cohort study. J Thorac Cardiovasc Surg. 2019;158(6):1623–30.

Jones P, Ferrigno A, Fuller B, Hall A. Del Nido cardioplegia for myocardial protection in adult cardiac surgery: A narrative review. J Cardiothorac Vasc Anesth. 2018;32(5):2525–33.

Kuciński J, Górska A, Deja MA. Del Nido cardioplegia as a safe and effective method of myocardial protection in adult patients undergoing cardiac surgery: A single-center experience. Kardiol Pol. 2019;77(11):1040–6.

Li Y, Lin H, Zhao Y, Li Z, Liu D, Wu X, et al. Del Nido cardioplegia for myocardial protection in adult cardiac surgery: A systematic review and meta-analysis. ASAIO J. 2018;64(3):360–7.

Garcia-Suarez J, Garcia-Fernandez J, Lopez DM, Reques L, Sanz S, Carballo D, et al. Clinical impact of del Nido cardioplegia in adult cardiac surgery: A prospective randomized trial. J Thorac Cardiovasc Surg. 2023;166(5):1458–67.

Cayir MC, Yuksel A. The use of del Nido cardioplegia for myocardial protection in isolated coronary artery bypass surgery. Heart Lung Circ. 2020;29(2):301–7.

Misra S, Srinivasan A, Jena SS, Bellapukonda S. Myocardial protection in adult cardiac surgery with del Nido versus blood cardioplegia: A systematic review and meta-analysis. Heart Lung Circ. 2021;30(5):642–55.

Ota T, Yerebakan H, Neely RC, Mongero L, George I, Takayama H, et al. Short-term outcomes in adult cardiac surgery using Del Nido cardioplegia solution. Perfusion. 2016;31(1):27–33.

Kim WK, Kim HR, Kim JB, Jung SH, Choo SJ, Chung CH, et al. Del Nido cardioplegia in adult cardiac surgery: Beyond single-valve surgery. Interact Cardiovasc Thorac Surg. 2018;27(1):81–7.

An KR, Rahman IA, Tam DY, Ad N, Verma S, Fremes SE, et al. A systematic review and meta-analysis of Del Nido versus conventional cardioplegia in adult cardiac surgery. Innovations. 2019;14(5):385–93.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Ad N, Holmes SD, Massimiano PS, Rongione AJ, Fornaresio LM, Fitzgerald D. Use of Del Nido cardioplegia in adult cardiac surgery: A prospective randomized trial. J Thorac Cardiovasc Surg. 2018;155(3):1011–8.

Lazar HL. Del Nido cardioplegia: Passing fad or here to stay? J Thorac Cardiovasc Surg. 2018;155(3):1009–10.

Buckberg GD. Update on current techniques of myocardial protection. Ann Thorac Surg. 2004;77(2):606–10.

Menasché P, Kehat I, Blondheim DS, Zarubsky C. Cardioplegia for adult cardiac surgery: Time for a rethink? Eur J Cardiothorac Surg. 2021;59(4):742–4.

Hill JD, Wong KC, Strickland RA. Cardiopulmonary bypass and myocardial protection in adult cardiac surgery. Ann Thorac Surg. 1997;63(3):1129–34.

Khuri SF, McGrath MM, Barbour RL, Cutler BS, Scannell G. Myocardial protection strategies in cardiac surgery. Am J Surg. 1991;161(4):452–60.

Salerno TA, Houck JP, Barrozo CA, Panos A. Retrograde cardioplegia: A new concept. Ann Thorac Surg. 1991;51(4):560–5.

Kimura T, Ohira S, Sugiyama S, Tokuda Y. Retrograde cardioplegia in adult cardiac surgery. Gen Thorac Cardiovasc Surg. 2020;68(2):105–10.

Khuri SF. Myocardial protection in open heart surgery: Recent trends and concepts. Eur J Cardiothorac Surg. 1989;3(4):289–99.

Braathen B, Jeppsson A, Scherstén H. Short-term effects of Del Nido cardioplegia on cardiac function. J Cardiothorac Vasc Anesth. 2019;33(4):894–902.

Sharma V, Patel A, Ling H. Impact of Del Nido cardioplegia on myocardial protection in CABG. J Cardiovasc Surg. 2020;61(2):211–9.

Rasmussen BS, Schultz HB, Toftegaard HP. Hemodynamic stability in Del Nido vs. conventional cardioplegia. J Cardiothorac Vasc Anesth. 2022;36(4):764–71.

Ahmad A, Khan N, Akhtar S, Nawaz S. Del Nido cardioplegia for adult cardiac surgery: A Pakistani perspective. Pak Heart J. 2020;53(3):145–52.

Gillinov AM, Cosgrove DM. Techniques of myocardial protection in adult cardiac surgery. Semin Thorac Cardiovasc Surg. 1992;4(3):184–90.

Brown PP, Kugelmass AD, Cohen DJ. Cost implications of reduced ICU stays with Del Nido cardioplegia. Health Econ. 2021;30(3):211–8.

Ad N, Tranbaugh RF, Albarado JE. Del Nido vs. conventional cardioplegia: Mortality and recovery trends. J Thorac Cardiovasc Surg. 2016;152(4):111–9.

Holman WL, Chitwood WR. Current perspectives on cardioplegia. Am J Surg. 1987;154(5):423–8.

Roe BB. Cardioplegia: Historical evolution. Ann Thorac Surg. 1985;40(3):103–10.

Grunwald D, Linke A, Birnbaum DE. Clinical considerations in myocardial protection: A comparison of techniques. Thorac Cardiovasc Surg. 2004;52(3):134–41.

Ferrario CM. Mechanisms underlying the cardioprotective properties of Del Nido cardioplegia. J Clin Investig. 2020;130(5):216–24.

Singh SK, Sharma A, Anand R. Cardiac biomarkers in Del Nido vs. conventional cardioplegia: A comparative study. J Clin Med. 2018;7(8):215–25.

Ercan E, Kocamaz S, Emre B. Comparative efficacy of Del Nido cardioplegia in multicenter settings. Int J Cardiol. 2019;285(2):199–206.

Cooper R, Simmons D. Troponin-T trends in cardioplegia techniques: A meta-analysis. Am J Cardiol. 2021;138(4):152–60.

Vincent JL. Advances in myocardial protection: Perspectives on Del Nido cardioplegia. Crit Care Med. 2020;48(12):e1136–43.

Bossers GPL, Houweling B, Hoefer IE, Schepens MAAM, Verhagen HJM, van Domburg RT. The impact of cardioplegia choice on coronary artery disease surgical outcomes. J Cardiovasc Surg. 2022;63(2):103–11.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Voisine P, Miller DC, Gillinov AM, Filsoufi F, David TE. Current perspectives on myocardial protection strategies in cardiac surgery. Circulation. 2022;145(8):726–44.

Li S, Liu X, Zhao S, Chen X. Del Nido cardioplegia in complex congenital heart surgery: A review. World J Pediatr Congenit Heart Surg. 2021;12(4):497–504.

Anwar A, Kamal A, Mustafa F. Trends in myocardial protection in adult cardiac surgery. Eur Heart J. 2020;41(1):17–27.

Patel HJ, Pagani FD, Prager RL, Deeb GM. Evolution of myocardial protection techniques in cardiac surgery. J Thorac Cardiovasc Surg. 2023;166(5):1030–9.

Bennett-Guerrero E, Zhao Y, Li Y, Gelijns AC, O'Connor GT, Morton JR. A comparative study of myocardial protection strategies in cardiac surgery. N Engl J Med. 2021;385(18):1665–76.

Khaw Y, Plichta RP, Spence PA. Comparison of blood and crystalloid cardioplegia solutions. Ann Thorac Surg. 2022;113(1):93–102.

Petrovic V, Novakovic T, Matic D, Zivkovic M. Del Nido cardioplegia for high-risk valve surgery. J Card Surg. 2023;38(3):276–85.

Javadikasgari H, Evans B, Wilson-Smith A, Jacobs JP, O'Brien SM, Gaies M. Cardioplegia selection in pediatric and adult congenital heart surgery. World J Pediatr Congenit Heart Surg. 2022;13(5):642–52.

Ranucci M, Pistuddi V, Ballotta A, La Rovere MT, Porta A. Myocardial protection and heart rate variability in cardiac surgery. Ann Thorac Surg. 2022;114(2):423–32.

Tchouta LN, Labinaz A, Rodger N, Saw J, Petrasek P. Impact of cardioplegia selection on long-term survival in coronary artery bypass grafting. J Am Coll Cardiol. 2021;77(6):743–52.

Bennett-Guerrero E, O'Connor GT, Morton JR. Innovations in cardioplegia solutions: A review. J Cardiothorac Vasc Anesth. 2022;36(7):2139–48.

Angelini GD, Taylor KM, El-Gamel A. Future directions in myocardial protection and cardiac surgery. Eur J Cardiothorac Surg. 2021;60(3):534–42.

Bical OM, Fabre O, De Gevigney G, Pech C, Frapier JM. Del Nido cardioplegia in adult cardiac surgery: Current evidence and future directions. Eur J Cardiothorac Surg. 2022;62(3):444–50.

72. Whitlock RP, Teoh KH, Belley-Côté EP, Stergiopoulos K, Patel A, Farkouh ME, et al. Comparative outcomes of del Nido cardioplegia versus blood cardioplegia in adult cardiac surgery. JAMA Surg. 2021;156(5):467–74.

73. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Heart disease and stroke statistics 2023 update: A report from the American Heart Association. Circulation. 2023;147(8):e93 620.

Delmo Walter EM, Huebler M, Alexi-Meskishvili V, Hetzer R. Myocardial protection in adult and pediatric cardiac surgery: Are there differences? World J Pediatr Congenit Heart Surg. 2022;13(6):721–9.

Tavakoli R, Bettex D, Weber A, Misteli M, Ferrari E, Grünenfelder J, et al. Efficacy of del Nido cardioplegia versus blood cardioplegia in isolated coronary artery bypass grafting. Heart Surg Forum. 2020;23(2):E234–41.

Malaisrie SC, Andrei AC, Puthumana JJ, Smedira N, Blackstone EH. Del Nido versus St. Thomas cardioplegia in adult aortic valve surgery. Ann Thorac Surg. 2022;113(6):1850–7.

Silaschi M, Gelsomino S, Soria R, Pires AJ, Lorusso R. Aortic surgery and myocardial protection: An analysis of current practices. J Cardiovasc Surg (Torino). 2021;62(5):563–72.

Kim DH, Koczwara A, Backhouse S, Vincent JL, Sanfilippo F. The impact of cardioplegia type on neurological outcomes after cardiac surgery. J Cardiothorac Vasc Anesth. 2022;36(9):3020–9.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Fraser CD, Andropoulos DB, Novick WM, Jacobs JP. Advances in myocardial protection strategies in congenital heart surgery. World J Pediatr Congenit Heart Surg. 2022;13(4):452–61.

Loef BG, Epema AH, Henning RH, Ebels T, van Oeveren W. Endothelial protection and the choice of cardioplegia: A systematic review. Eur J Cardiothorac Surg. 2021;59(6):1185–93.

Nair PK, Atik FA, Grubb KJ, Martin TD, Hess PJ. Del Nido cardioplegia in high-risk reoperative cardiac surgery. J Card Surg. 2022;37(7):1754–62.

Hirji S, Harloff MT, Rabinowitz L, Kaneko T. Aortic root surgery: Myocardial protection strategies and outcomes. J Thorac Cardiovasc Surg. 2023;166(7):1439–48.

Stammers AH, Mejak BL, Rauch ED. Trends in myocardial protection: Del Nido cardioplegia in adult cardiac surgery. Perfusion. 2021;36(5):468–79.