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Original Article

Urgent isolated coronary artery bypass grafting: Del nido cardioplegia versus cold blood cardioplegia—A retrospective propensity-matched analysis

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Abstract

Aim: To compare myocardial protection and short-term clinical outcomes associated with Del Nido cardioplegia (DNC) versus cold blood cardioplegia (CBC) in patients undergoing urgent isolated coronary artery bypass grafting (CABG).
Materials and Methods: We retrospectively evaluated consecutive patients who underwent urgent isolated CABG at a single tertiary center between January 2018 and September 2020 (n=127). Propensity score matching was performed in a 1:1 ratio with a caliper width of 0.2 standard deviations (SD), yielding two well-balanced cohorts: DNC (n=64) and CBC (n=63). The primary endpoint was the change in serum troponin-I at 24 hours postoperativel. Secondary endpoints included changes in creatine kinase-MB (CK-MB), spontaneous return to sinus rhythm following reperfusion, vasoactive-inotropic score (VIS), intra-aortic balloon pump (IABP) requirement, and 30-day mortality. High-sensitivity troponin-I levels were measured at baseline and at 6, 12, and 24 hours postoperatively. Temporal biomarker trends were analyzed using linear mixed-effects models. Multivariable logistic regression with bootstrap validation was applied to identify predictors of absent spontaneous rhythm after reperfusion. Post-matching statistical power analyses were performed.
Results: The matched cohorts were well balanced across demographic, angiographic, and operative variables (all standardized mean differences <0.1). At 6 hours postoperatively, median delta troponin-I was 1102 ng/L (interquartile range [IQR] 820–1380) in the DNC group and 1094 ng/L (IQR 800–1320) in the CBC group. Mean delta CK-MB at 6 hours was 45±20 ng/mL for DNC and 48±22 ng/mL for CBC. Spontaneous rhythm recovery occurred more frequently with DNC (59.4% vs 20.6%). After adjustment for left ventricular ejection fraction (LVEF), aortic cross-clamp (ACC) time, and admission glucose level, DNC was associated with a lower likelihood of absent spontaneous rhythm (odds ratio 0.17;95% confidence interval 0.07–0.42). Total cardioplegia volume was significantly lower with DNC (1400±200 mL vs 1909.5±453.9 mL). VIS, prolonged inotrope use (>4 hours), IABP requirement, and 30-day mortality were comparable between groups.
Conclusion: In this propensity-matched analysis of urgent isolated CABG, DNC provided myocardial protection and early clinical outcomes comparable to CBC, while improving spontaneous rhythm recovery and reducing cardioplegia volume. These findings support clinical equipoise and inform the design of future randomized controlled trials.

Keywords: Del nido cardioplegia, cold blood cardioplegia, urgent coronary artery bypass grafting, myocardial protection, troponin I, propensity score matching

INTRODUCTION

Optimal myocardial protection is fundamental to achieving favorable perioperative outcomes and procedural success in cardiac surgery (1). Although hypothermic, hyperkalemic cardioplegic solutions remain the standard of care in adult cardiac procedures, the optimal formulation continues to be debated (2). Initially developed for pediatric cardiac surgery, del Nido cardioplegia (DNC) has gained increasing acceptance in adult populations, supported by a growing body of observational studies and systematic reviews demonstrating its safety and efficacy (3,4). Contemporary randomized trials and meta-analyses indicate that DNC provides biochemical and clinical outcomes comparable to those of conventional cold blood cardioplegia (CBC) in elective adult cardiac surgery, while potentially reducing operative complexity and myocardial edema. However, evidence specific to urgent coronary artery bypass grafting (CABG)—a clinical setting characterized by heightened

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inflammatory responses, variable ischemic burden, and increased susceptibility to reperfusion injury—remains limited.

Urgent CABG—defined as surgical revascularization performed within 24 hours for refractory unstable angina or non–ST-elevation myocardial infarction—poses distinct clinical and technical challenges. These include complex coronary anatomy, heterogeneous preoperative exposure to antithrombotic therapy, and potentially prolonged periods of myocardial ischemia, all of which may influence the effectiveness of cardioplegic strategies (5,6).

We hypothesized that, in patients undergoing stable urgent isolated CABG, DNC would provide myocardial protection comparable to that of CBC, while potentially enhancing electrophysiological recovery following reperfusion.

Accordingly, this study sought to address a critical gap in the literature by comparing the efficacy of del Nido versus CBC in high-risk patients undergoing stable urgent isolated CABG.

MATERIALS AND METHODS

Ethics Approval

The study protocol was reviewed and approved by the Ethics Committee of Bursa Yüksek İhtisas Training and Research Hospital (approval date: September 22, 2021; reference number: 2021-171). All procedures were conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Owing to the retrospective nature of the study, the requirement for informed consent was waived. All patient data were anonymized in accordance with the Personal Data Protection Law No. 6698, and no additional medical interventions or procedures were performed as part of this study.

Study Population

We retrospectively analyzed consecutive patients who underwent urgent isolated CABG at a single tertiary care center between January 2018 and September 2020 (n=127). Following comprehensive data review, propensity score matching was performed in a 1:1 ratio using a caliper width of 0.2 SD, resulting in two well-balanced cohorts: DNC (n=64) and CBC (n=63).

Urgent surgical indication was defined as refractory unstable angina or non–ST-elevation myocardial infarction requiring revascularization within 24 hours, in accordance with European Society of Cardiology/European Association for Cardio-Thoracic Surgery guidelines. Owing to the retrospective design, treatment allocation was nonrandomized; therefore, propensity score matching was used to minimize baseline differences between groups. These inclusion criteria restricted the study population to hemodynamically stable patients undergoing urgent isolated CABG.

Inclusion Criteria

Consecutive adult patients (≥18 years) who underwent urgent isolated CABG between January 2018 and September 2020 were included. Urgent CABG was defined according to the European Society of Cardiology and European Association for Cardio-Thoracic Surgery guidelines on myocardial revascularization applicable during the study period (7).

Exclusion Criteria

Patients presenting with cardiogenic shock, those requiring active resuscitation, individuals with mechanical complications of myocardial infarction, patients undergoing redo cardiac surgery, off-pump CABG, or procedures involving concomitant valvular or aortic interventions were excluded to ensure a homogeneous study cohort (8). In addition, patients receiving preoperative mechanical circulatory support, including intra-aortic balloon pump therapy, were excluded. By excluding patients with overt hemodynamic instability, the study findings primarily reflect outcomes in urgent yet hemodynamically stable surgical populations.

Operative Technique and Cardioplegia Protocols

All procedures were performed via median sternotomy under general anesthesia using standard cardiopulmonary bypass (CPB) with systemic anticoagulation, targeting an activated clotting time >480 seconds. ACC was routinely employed, with antegrade, retrograde, or combined antegrade–retrograde cardioplegia delivery selected according to coronary anatomy (9).

For DNC, an initial dose of 20 mL/kg (approximately 1,400 mL; blood-to-crystalloid ratio, 1:4) was administered. In accordance with institutional protocol, patients with significant left ventricular hypertrophy (LVH) or an anticipated ACC duration exceeding 60 minutes received a single supplemental dose of DNC (10 mL/kg) administered 60 minutes after the initial infusion. This approach is supported by evidence suggesting that myocardial protection from a single del Nido dose may be inadequate in the setting of prolonged ischemia or marked myocardial hypertrophy. In the present cohort, only 3 of 64 patients (4.7%) required a repeat dose (10).

CBC was prepared by mixing 300 mL of oxygenated CPB blood with 10 mEq potassium chloride and sodium bicarbonate. An initial dose of 10 mL/kg was administered, followed by maintenance doses of 5 mL/kg every 20 minutes (11). Both cardioplegic solutions were delivered at 4–10°C, with adjunctive topical myocardial cooling. Perfusion and anesthetic management were conducted in accordance with institutional standards (12).

Data Collection and Definitions

Preoperative data included demographic characteristics (age and sex), comorbidities (hypertension and diabetes mellitus), body mass index, LVEF, EuroSCORE II, Society of Thoracic Surgeons (STS) score, and baseline high-sensitivity troponin I levels (13). Intraoperative variables comprised ACC time, CPB duration, and total volume of cardioplegia administered (14). Postoperative data included serial measurements of high-sensitivity troponin I and CK-MB at baseline and at 6, 12, and 24 hours after surgery; the vasoactive-inotropic score (VIS), calculated using the Gaies formula, during the first 24 postoperative hours; IABP utilization; prolonged inotropic support (>4 hours); spontaneous restoration of cardiac rhythm after reperfusion; and 30-day all-cause mortality (15,16).

In patients presenting with non–ST-segment elevation myocardial infarction (NSTEMI) and elevated baseline troponin levels, delta troponin values were calculated, and baseline troponin concentrations were included as covariates in the statistical models to account for preexisting myocardial injury (17).

Study Outcomes

The primary outcome was the change in serum high-sensitivity troponin I levels at 24 hours postoperatively. Secondary outcomes included changes in CK-MB levels; spontaneous restoration of sinus rhythm after reperfusion; vasoactive-inotropic score (VIS); IABP requirement; prolonged inotropic support (>4 hours); length of stay in the intensive care unit and hospital; and 30-day all-cause mortality. Exploratory outcomes included duration of mechanical ventilation and the occurrence of postoperative atrial fibrillation (AF). Definitions of safety outcomes and arrhythmia classifications were prospectively standardized and applied uniformly across the study cohort (18).

Propensity Score Matching and Variable Selection

To reduce selection bias, propensity scores were estimated using logistic regression, incorporating clinically relevant preoperative covariates: age, sex, EuroSCORE II, LVEF, diabetes mellitus, hypertension, body mass index, STS score, and baseline high-sensitivity troponin I levels (19). This comprehensive covariate set was selected to mitigate the limitations associated with parsimonious matching models (20). One-to-one nearest-neighbor matching without replacement was performed using a caliper width of 0.2 SD of the logit of the propensity score. Covariate balance was evaluated using standardized mean differences (SMDs) and visualized with Love plots; an SMD <0.1 was considered indicative of adequate balance (21). Details regarding the matching procedure, statistical software (R version 4.3.2; MatchIt package), and analysis scripts are provided in the Supplementary Material.

Statistical Analysis

Continuous variables are presented as mean ± SD or median with interquartile range (IQR), as appropriate, while categorical variables are reported as frequencies and percentages. Between-group comparisons were performed using Student's t-test or Welch's t-test for normally distributed continuous variables, the Mann–Whitney U test for non-normally distributed variables, and the chi-square or Fisher's exact test for categorical variables, as appropriate (22).

Longitudinal trajectories of biochemical markers were analyzed using linear mixed-effects models with random intercepts for individual patients and fixed effects for treatment group, time, and their interaction. In patients with non–ST-segment elevation myocardial infarction (NSTEMI), baseline troponin levels were included as a covariate to account for preexisting myocardial injury (23). Logistic regression was used to identify predictors of absent spontaneous rhythm restoration, incorporating variables with $p < 0.10$ in univariate analyses; the complete list of candidate predictors and the events-per-variable ratio are provided in the Supplementary Tables (24).

Model performance was assessed by evaluating calibration using the Hosmer–Lemeshow goodness-of-fit test and discrimination using the area under the receiver operating characteristic curve (AUC). Internal validation was conducted using bootstrap resampling with 1,000 iterations (25). To account for multiple comparisons, Bonferroni correction was applied to pairwise comparisons in analyses of biochemical marker trajectories, whereas the false discovery rate approach was used for exploratory subgroup analyses. Details of multiplicity adjustments are provided in the Supplementary Analyses. Post-matching sample size and statistical power for key endpoints were recalculated (26). All statistical tests were two-sided, and a p value < 0.05 was considered statistically significant. Statistical analyses were performed using R software (version 4.3.2; MatchIt, lme4, ggplot2) and SPSS software (version 28.0).

Data Availability and Reproducibility

De-identified individual-level data and the statistical analysis scripts are available from the corresponding author upon reasonable request, subject to institutional data-sharing agreements. Detailed study protocols and analytical procedures are provided in the Supplementary Materials. The study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis (TRIPOD) guidelines.

RESULTS

Patient Selection and Matching Assessment

A total of 127 consecutive patients undergoing urgent isolated CABG met the inclusion criteria and were included in the initial analysis. After propensity score matching using an extended set of preoperative covariates, 64 patients in the DNC group and 63 patients in the CBC group were successfully matched. Post-matching assessments demonstrated adequate covariate balance, with all SMDs below 0.1. Corresponding Love plots and SMD summaries are provided in the Supplementary Materials.

The effective post-matching sample size yielded at least 80% statistical power for the primary endpoint (change in troponin I levels), whereas selected secondary and low-frequency outcomes demonstrated statistical power below 80%, as reported for each endpoint. Baseline characteristics of the matched cohorts are summarized in Table 1, with all covariates achieving SMDs <0.1. After matching, the two groups were comparable with respect to the extent of coronary artery disease, preoperative LVEF, and major comorbidities, as confirmed by the standardized mean differences (Table 1).

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Operative Characteristics

The mean ACC time was 66.4 ± 17.7 minutes in the DNC group and 73.9±30.6 minutes in the CBC group (p=0.10). Mean CPB duration was 98.9±26.8 minutes for DNC versus 103.9±38.1 minutes for CBC (p=0.398). The total cardioplegia volume was significantly lower with DNC (1400±200 mL) compared to CBC (1909.5±453.9 mL, p<0.001) (Table 2).

Biochemical and Hemodynamic Findings

At 6 hours postoperatively, the median delta troponin-I was 1102 ng/L (IQR 820–1380) for the DNC group and 1094 ng/L (IQR 800–1320) for the CBC group (p=0.945). The mean delta CK-MB at 6 hours was 45±20 ng/mL for DNC and 48±22 ng/mL for CBC (p=0.82). Linear mixed-effects modeling revealed no significant group-by-time interaction for troponin trajectories (p>0.05) (Table 3). The mean VIS was 8.2 ± 3.1 for DNC and 7.9±2.8 for CBC (p=0.78). Prolonged inotrope use (>4 hours) occurred in 34.4% of DNC patients and 28.5% of CBC patients (p=0.568). IABP support was required in 4.7% of DNC and 9.5% of CBC patients (p=0.238). Thirty-day mortality rates were comparable between groups (DNC 4.7% vs CBC 4.8%, p=0.653) (Table 2). No significant differences were observed in ventilation duration (DNC 12.5±4.2 hours vs CBC 13.1±4.5 hours) or postoperative atrial fibrillation (DNC 15.6% vs CBC 17.5%).

Reperfusion Rhythm and Adjusted Analyses

Spontaneous return to sinus rhythm following reperfusion was significantly more frequent in the DNC group (59.4%) compared to the CBC group (20.6%) (p<0.001) (Table 2). Multivariable logistic regression analysis for absent spontaneous rhythm (coded as 1= absent) included covariates for LVEF, ACC duration, admission glucose, baseline troponin, and cardioplegia type. The model met the events-per-variable criterion. DNC use was independently associated with a lower likelihood of absent spontaneous rhythm (adjusted OR 0.17, 95% CI 0.07–0.42, p<0.001) (Table 4). Model calibration was acceptable (Hosmer–Lemeshow p=0.72), and bootstrap validation confirmed robustness. Sensitivity analyses showed consistent trends, though some comparisons were underpowered. No other major postoperative complications differed significantly between groups. In the multivariable analysis, fasting glucose was identified as an independent predictor of absent spontaneous rhythm, with an odds ratio of 0.99 (p=0.023). While the effect size was small, this association suggests that higher preoperative glucose levels may negatively impact electrophysiologic recovery following reperfusion. Previous studies have linked hyperglycemia to increased susceptibility to ischemia–reperfusion injury and disruptions in myocardial ion homeostasis, mechanisms that may also explain the findings observed in our cohort. These results underscore the need for further investigation in larger, prospective studies, particularly in urgent surgical settings where metabolic instability is common.

Exploratory Subgroup Analyses

In the predefined subgroup of patients with low LVEF (<35%;n=15), statistical power was limited. Descriptively, spontaneous rhythm recovery appeared higher in the DNC group (50% vs. 25%), though interaction effects were not significant. These findings are hypothesis-generating and require confirmation in adequately powered prospective trials.

Table 1. Baseline demographic and preoperative characteristics after propensity score matching

Variable	DNC (n=64)	CBC (n=63)	p-value
Age, years	61.2 ± 8.1	62.6 ± 9.2	0.352
Female, %	20.3	15.9	0.509
Hypertension, %	46.9	52.4	0.595
Diabetes, %	42.1	33.3	0.346
BMI, kg/m²	24.8 ± 3.1	25.6 ± 3.3	0.178
LVEF, %	51.6 ± 7.0	48.7 ± 9.0	0.062
EuroSCORE II	2.8 ± 1.2	2.9 ± 1.3	0.854
STS score	1.2 ± 0.5	1.3 ± 0.6	0.724
Baseline troponin-I, ng/L	450 (200–620)	480 (210–650)	0.724

BMI: body mass index, CBC: conventional blood cardioplegia, DNC: del Nido cardioplegia, IQR: interquartile range, LVEF: left ventricular ejection fraction, SD: standard deviation, STS: Society of Thoracic Surgeons

Table 2. Intraoperative and early postoperative outcomes

Variable	DNC	CBC	p-value
Aortic cross-clamp time, min	66.4 ± 17.7	73.9 ± 30.6	0.10
CPB time, min	98.9 ± 26.8	103.9 ± 38.1	0.398
Total cardioplegia volume, mL	1400 ± 200	1909.5 ± 453.9	<0.001
Spontaneous sinus rhythm at reperfusion, %	59.4	20.6	<0.001
Delta troponin-I at 6 h, ng/L median (IQR)	1102 (820–1380)	1094 (800–1320)	0.945
Delta CK-MB at 6 h, ng/mL mean ± SD	45 ± 20	48 ± 22	0.82
VIS score mean ± SD	8.2 ± 3.1	7.9 ± 2.8	0.78
Inotropic support >4 h, %	34.4	28.5	0.568
IABP use, %	4.7	9.5	0.238
30-day mortality, %	4.7	4.8	0.653

CBC: conventional blood cardioplegia, CK-MB: creatine kinase–myocardial band, CPB: cardiopulmonary bypass, DNC: del Nido cardioplegia, IABP: intra-aortic balloon pump, IQR: interquartile range, SD: standard deviation, VIS: vasoactive–inotropic score

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Table 3. Postoperative delta troponin-I time course

Postoperative Time, h	DNC median ng/L	CBC median ng/L
0	0	0
6	1102	1094
12	830	836
24	545	608

CBC: conventional blood cardioplegia, DNC: del Nido cardioplegia, IQR: interquartile range

Table 4. Multivariable logistic regression analysis for absence of spontaneous rhythm

Predictor	Odds Ratio	95% CI	p-value
Del Nido cardioplegia use	0.17	0.07–0.42	<0.001
Fasting glucose, mg/dL	0.99	0.98–1.00	0.023
LVEF, %	0.99	0.94–1.05	0.768
Aortic cross-clamp time, min	1.01	0.99–1.03	0.599

CI: confidence interval, LVEF: left ventricular ejection fraction

DISCUSSION

In this propensity score–matched cohort incorporating detailed operative variables, DNC provided myocardial protection comparable to that of CBC, as reflected by equivalent biochemical markers (troponin-I and CK-MB) and early postoperative outcomes in patients undergoing urgent isolated CABG. Importantly, DNC was associated with a higher rate of spontaneous sinus rhythm recovery following reperfusion and a significantly reduced cardioplegia volume. These associations remained consistent after multivariable adjustment and internal validation procedures (3,4).

The significantly higher rate of spontaneous sinus rhythm recovery in the DNC group may reflect more favorable electrophysiological stability during reperfusion, possibly mediated by lidocaine-based sodium channel blockade and reduced calcium influx (10,11). This early rhythm stability with DNC may translate into fewer postoperative arrhythmias, such as atrial fibrillation, or reduced pacing requirements, as suggested by existing literature on lidocaine-based cardioplegia. The better rhythm recovery may be attributed to lidocaine-mediated sodium channel blockade, which reduces intracellular calcium influx, prevents reperfusion-induced contracture, and improves electrophysiologic stability (10). However, whether these short-term rhythm benefits translate into long-term electrophysiologic stability remains uncertain, underscoring the need for prospective trials with extended follow-up to assess arrhythmia recurrence and pacemaker requirements (14).

Recent comparative studies have highlighted potential metabolic and hemodynamic advantages of DNC over CBC. DNC has been associated with lower intraoperative glucose concentrations and reduced insulin requirements, likely attributable to its glucose-free crystalloid base and improved myocardial metabolic stability during ischemia. Several investigations have also reported shorter ACC and CPB durations, reduced inotropic support, and superior early postoperative LVEF, suggesting enhanced myocardial recovery and attenuated ischemia–reperfusion injury. Moreover, DNC has been linked to smaller postoperative elevations in cardiac biomarkers, including troponin T, CK-MB, and pro–B-type natriuretic peptide, indicating reduced cellular injury and ventricular strain. The solution's low calcium content may further limit intracellular calcium accumulation, thereby minimizing reperfusion-induced contracture and arrhythmogenicity (7).

Clinically, several series have demonstrated shorter durations of mechanical ventilation, reduced transfusion requirements—particularly of packed red blood cells—and decreased intensive care unit and overall hospital length of stay compared with CBC. Improved microcirculatory flow resulting from lower hematocrit and blood viscosity associated with DNC may contribute to these favorable outcomes, while selective use of ultrafiltration has been reported to mitigate potential hemodilution during prolonged procedures (8). Collectively, these findings suggest that DNC provides effective myocardial protection with favorable systemic effects and support its use not only in pediatric and elective adult surgery but also across emergency and high-risk reoperative cardiac procedures (27).

Our findings are largely consistent with recent meta-analyses and propensity score–matched studies demonstrating comparable myocardial injury biomarker levels between DNC and CBC in adult cardiac surgery. Randomized controlled trials have similarly reported equivalent perioperative troponin and CK-MB trajectories, supporting the premise that DNC provides effective myocardial protection despite its single-dose administration strategy. In contrast to several elective-surgery cohorts in which DNC has been associated with shorter ACC and CPB durations, we did not observe significant differences in operative times, likely reflecting the urgency and procedural complexity characteristic of this patient population. The substantially higher rate of spontaneous rhythm recovery observed in the DNC group aligns with reports from minimally invasive valve surgery and high-risk coronary procedures, suggesting a reproducible electrophysiologic benefit. Nonetheless, discrepancies in the literature—particularly regarding postoperative hemodynamics and inotropic requirements—persist, as published findings remain heterogeneous across study designs and populations.

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Collectively, these observations support DNC as a reliable alternative to CBC across a range of surgical contexts, while highlighting considerations unique to urgent CABG.

At our institution, DNC is routinely used in most elective adult cardiac procedures, particularly isolated valve surgery and standard coronary revascularization, owing to its ease of administration and consistent myocardial protection profile. This strategy is modified only in select high-risk scenarios—such as severe LVH, significant aortic regurgitation, or anticipated prolonged ischemic intervals—where supplemental dosing is employed. Although this approach does not differ substantially in urgent cases, the final strategy is individualized based on preoperative hemodynamic status, coronary anatomy, and the anticipated duration of ACC.

Limitations

This retrospective, single-center analysis is subject to inherent risks of residual confounding, despite the application of robust propensity score matching and bootstrap validation techniques (21,22). The exclusion of patients presenting with cardiogenic shock limits the generalizability of these findings to hemodynamically stable patients undergoing urgent CABG, rather than to the full spectrum of emergency cardiac surgical presentations (8). In addition, the study was underpowered for several secondary outcomes, limiting the interpretability of non-significant results and increasing the risk of type II error. Although statistical power was adequate for the primary endpoint, several secondary and exploratory analyses remained underpowered, warranting cautious interpretation (9,25). Finally, despite adherence to rigorous methodological standards and transparent reporting practices, causal inferences should be deferred to future randomized controlled trials (26).

CONCLUSION

In this propensity score–matched cohort of patients undergoing urgent isolated CABG with comprehensive covariate adjustment, DNC demonstrated myocardial injury biomarker profiles and early postoperative outcomes comparable to those of CBC, while achieving significantly higher rates of spontaneous rhythm recovery and reduced cardioplegia volume. These findings support the need for adequately powered randomized controlled trials incorporating electrophysiologic and long-term clinical endpoints to formally test non-inferiority or superiority hypotheses. Based on the present results, DNC appears to be a viable alternative to CBC in urgent isolated CABG, particularly with respect to improved rhythm recovery and procedural efficiency.

Future investigations should further elucidate the mechanistic role of the lidocaine component of DNC in reducing defibrillation requirements and modulating myocardial ischemia–reperfusion injury.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The study protocol was reviewed and approved by the Ethics Committee of Bursa Yüksek İhtisas Training and Research Hospital (approval date: September 22, 2021; reference number: 2021-171).

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