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Original Article

Early Results of Coronary Artery Bypass Grafting in Patients on Dialysis

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ABSTRACT

Background: While coronary artery bypass grafting CABG (Coronary Artery Bypass Grafting) is the preferred revascularization strategy for multi-vessel disease in dialysis patients, perioperative risk remains prohibitive. The relative prognostic importance of renal versus cardiac parameters is poorly defined, and the optimal surgical conduit strategy is debated. This study aimed to evaluate the early mortality and morbidity of dialysis-dependent patients undergoing isolated CABG and to identify independent predictors of early survival.

Methods: We prospectively studied 100 dialysis-dependent patients undergoing isolated CABG under a standardised multidisciplinary protocol conducted between January 2022 and March 2023 in the National Heart Institute, Cairo, Egypt. We analysed early (30-day) outcomes and performed regression modelling to identify predictors of mortality.

Results: We observed an early mortality rate of 7%. Contrary to conventional cardiac surgical risk models, in this exploratory multivariate model, we identified elevated baseline serum creatinine (odds ratio, 3.46; P = 0.029) as a potential independent predictor of death; left ventricular function was not predictive. The cohort exhibited a distinct morbidity profile, with high rates of bleeding (11%) and infection (3%). Notably, the left internal mammary artery was utilized in only 6% of cases, with saphenous vein grafts serving as the primary conduit for revascularization.

Conclusions: This study challenges the primacy of cardiac metrics in risk-stratifying dialysis patients for CABG, establishing preoperative renal function as the dominant prognostic factor. Our findings justify a paradigm shift in preoperative optimization and support a patient-centered surgical approach that may selectively eschew standard arterial grafting to safeguard critical dialysis access. This tailored strategy yielded mortality rates favorable to contemporary benchmarks.

Key words: End-stage renal disease, cardiovascular surgical procedures, risk assessment, internal mammary-coronary artery anastomosis, perioperative care

INTRODUCTION

The chronic renal failure population exhibits a significantly elevated prevalence of coronary artery disease and, consequently, a high burden of cardiovascular mortality. Cardiovascular pathology, primarily encompassing heart failure and myocardial infarction, accounts for nearly fifty percent of all fatalities observed in patients with end-stage renal disease (ESRD). [1, 2] Advancements in dialysis therapy have led to a progressive rise in the prevalence of individuals living with ESRD. As an established revascularization technique for multi-vessel disease, coronary artery bypass grafting

(CABG) is often the preferred intervention for this population, owing to the poor outcomes associated with percutaneous coronary intervention. [3]

Dialysis-dependent patients with ESRD constitute a high-risk cardiac surgical population, primarily due to the complex pathophysiological sequelae of uremia, including accelerated vascular disease, coagulopathy, dyslipidemia, and severe fluid and electrolyte imbalance. [4–6] Consequently, perioperative mortality in this patient population is substantially elevated; cardiac surgery mortality for ESRD patients has been reported to be 3.9-fold higher than for non-ESRD counterparts. [7, 8]

Given the clinical challenges, achieving favorable outcomes requires specialized care. The study approach involved strict adherence to routine dialysis protocols, facilitated by nephrology consultation and ultrafiltration, aligning the surgery with the patient's clinical needs.

In this report, we present our findings regarding the early mortality and morbidity associated with isolated CABG in chronic dialysis patients. We hypothesized that in dialysis-dependent patients, preoperative metabolic and renal markers are more significant predictors of 30-day mortality than traditional echocardiographic parameters. Consequently, the primary objective of this study was to evaluate early postoperative outcomes and determine the clinical variables that serve as independent predictors of mortality in this high-risk population.

MATERIALS AND METHODS

Study Design and Patient Population

This prospective observational study was conducted at the Cardio-Thoracic Surgery Department of the National Heart Institute Hospital. The study cohort comprised 100 consecutive patients with ESRD, all of them on chronic hemodialysis, who underwent isolated CABG between January 2022 and March 2023. A formal pre-study power calculation was not performed due to the specific and limited nature of the dialysis-dependent population available at our center.

Inclusion and Exclusion Criteria

Inclusion criteria: The study cohort comprised 100 consecutive patients with ESRD on chronic dialysis who required isolated CABG.

Exclusion criteria: To ensure cohort consistency, we excluded patients with: (1) significant concomitant valvular pathology (moderate-to-severe stenosis or regurgitation as determined by pre-operative transthoracic echocardiography), (2) significant liver disease (known cirrhosis or biochemical evidence of advanced hepatic dysfunction (e.g., Child-Pugh Class B or C), (3) redo cardiac surgery (any patient with a history of prior sternotomy), and (4) emergency clinical presentation (patients requiring surgical intervention within 24 hours of admission due to hemodynamic instability or refractory ischemia).

Clinical Management and Data Acquisition

All participants underwent a standardized preoperative evaluation, which included a comprehensive history, a physical examination (assessing hemodynamic and fluid status), and a complete laboratory panel comprising hematologic, hepatic, and renal profiles. Cardiac status was stratified using electrocardiography, chest radiography, and transthoracic echocardiography.

Intraoperative parameters, including cardiopulmonary bypass time, cross-clamp time, and operative complications, were prospectively recorded. Postoperative management focused on hemodynamic stability, indicated by inotropic requirements and ICU duration, alongside morbidity and mortality surveillance. A specific emphasis was placed on renal management, with complete dialysis reports and discharge echocardiography utilized to assess early outcomes.

Renal Management and Dialysis Protocol

All patients followed a standardized perioperative dialysis protocol developed by a multidisciplinary team (cardiac surgery, nephrology, anesthesia). The last hemodialysis session was performed 24 hours before surgery to optimize volume status and normalize electrolytes while avoiding residual intraoperative anticoagulation. Intraoperatively, modified ultrafiltration was employed during cardiopulmonary bypass to manage fluid balance. Postoperatively, renal replacement therapy was initiated within 24 to 48 hours, preferentially using continuous renal replacement therapy (CRRT) or sustained low-efficiency dialysis in hemodynamically unstable patients, transitioning to intermittent hemodialysis as tolerated. Dialysis was performed daily or on alternate days until clinical stability was achieved, with careful attention to fluid removal rates and regional citrate anticoagulation (RCA) where applicable. For postoperative CRRT, RCA was utilized to maintain circuit patency while minimizing systemic heparinization. The protocol targeted a post-filter ionized calcium (iCa) level of 0.25 to 0.35 mmol/L to achieve effective regional anticoagulation, while maintaining systemic iCa levels between 1.1 and 1.3 mmol/L via a continuous calcium gluconate infusion. This multidisciplinary approach allowed for therapeutic dialysis efficiency without exacerbating the uremic coagulopathy or increasing the risk of surgical site hemorrhage.

Statistical Analysis

Analyses were performed with IBM SPSS Statistics, version 26.0. Continuous variables are summarized as mean ± standard deviation; categorical variables as number (%). Predictors of early mortality were evaluated using univariate logistic regression. All variables with $P < 0.20$ on univariate analysis were entered into a multivariable logistic regression model using the forced entry method. Given the low number of outcome events (n = 7), which results in a low events-per-variable ratio, the multivariable results are presented as exploratory and hypothesis-generating to avoid over-interpretation of a potentially overfitted model. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided *P*-value of 0.05 was used to define statistical significance.

Ethical Considerations

This study was approved by the Institutional Review Board (IHC 00119) of the National Heart Institute Hospital. All procedures were performed in accordance with the ethical standards of the institutional and/or national research

committee and with the 1964 Helsinki Declaration and its later amendments. Informed written consent was obtained from all individual participants included in the study.

RESULTS

Demographic and Clinical Characteristics

This study of 100 dialysis-dependent patients undergoing isolated CABG reveals a high-risk surgical cohort with substantial early mortality (7%) and morbidity. Patients were predominantly male (84%) with a mean age of 61 years and carried a heavy burden of diabetes (51%), hypertension (63%), and advanced coronary disease (58% three-vessel). Notably, preoperative renal dysfunction was profound, with a mean serum creatinine of 7.5 mg/dL (**Table 1**).

Surgical Aspects

Surgically, the use of the left internal mammary artery (LIMA) was remarkably low (6%), with saphenous vein grafts serving as the principal conduit for LAD revascularization. Most operations were performed on the pump (84%; **Table 2**).

Complications of the Surgery

Following surgery, complications were frequent, including an 11% rate of re-exploration for bleeding and a 3% incidence of mediastinitis. Systolic function deteriorated postoperatively, with ejection fraction falling by nearly 9 percentage points on average (**Table 3**).

Mortality and Predictors of Survival

Exploratory regression analysis suggested a significant association between baseline renal function and survival. While several factors (ejection fraction [EF], mechanical ventilation) showed significance in univariate analysis, only elevated baseline serum creatinine (OR, 3.46; P = 0.029)

Table 2: Intraoperative details.

Characteristic	Mean ± SD or n (%)
Surgical technique	
On-pump/off-pump	84 (84.0%)/16 (16.0%)
Total operative time (hours)	3.78 ± 0.57
CPB time (min)	85.53 ± 22.95
Cross-clamp time (min)	62.92 ± 18.31
Conduit utilization	
LIMA on LAD	6 (6.0%)
Saphenous vein on LAD	94 (94.0%)
Grafted coronary arteries	
LAD	100 (100.0%)
Obtuse marginal	61 (61.0%)
Diagonal	39 (39.0%)
Posterior descending artery	19 (19.0%)
Distal right coronary artery	28 (28.0%)

CPB, cardiopulmonary bypass; LIMA, left internal mammary artery; LAD, left anterior descending artery.

Table 1: Baseline patient characteristics (N = 100).

Characteristic	Mean ± SD or n (%)
Demographics	
Age (years)	60.81 ± 4.03
Male gender	84 (84.0%)
Body surface area (m^2)	1.78 ± 0.13
Comorbidities	
Diabetes mellitus	51 (51.0%)
Hypertension	63 (63.0%)
Smoking	60 (60.0%)
Clinical presentation	
Chest pain	100 (100.0%)
Dyspnea	70 (70.0%)
CCS angina class	
Class III	94 (94.0%)
Class IV	6 (6.0%)
Pre-operative laboratory	
Creatinine (mg/dL)	7.51 ± 1.58
GFR (mL/min/1.73 m^2)	12.09 ± 1.49
HbA1c (Hemoglobin A1c) (%)	6.61 ± 1.07
Pre-operative echocardiography	
Ejection fraction (%)	50.25 ± 7.56
LVEDD (cm)/LVESD (cm)	5.33 ± 0.60/3.35 ± 0.52
Coronary angiography	
Left main disease	5 (5.0%)
Single/two/three-vessel disease	3 (3.0%)/34 (34.0%)/58 (58.0%)

CCS, Canadian Cardiovascular Society; GFR, glomerular filtration rate; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter.

maintained a significant association in the exploratory multivariable model. These preliminary findings suggest that preoperative uremic burden may carry significant prognostic weight, potentially overshadowing traditional cardiac metrics in this specific high-risk cohort (**Table 4**).

Multivariate results are considered exploratory and hypothesis-generating due to the low number of outcome events (n = 7), which results in a low events-per-variable ratio and a risk of model overfitting.

DISCUSSION

Mortality Outcomes in the Context of High-Risk ESRD

Patients with ESRD undergoing maintenance dialysis represent a distinct high-risk cohort within adult cardiac surgery. Cardiovascular disease accounts for nearly 50% of mortality in this population. While CABG is the preferred revascularization strategy for multi-vessel disease, it has historically carried a high perioperative risk.

In the present study, we observed an early mortality rate of 7.0%. When contextualized against contemporary literature, this outcome compares favorably to international benchmarks. A 2025 nationwide cohort analysis reported a 21-day post-operative mortality rate of 12.3% for dialysis patients undergoing on-pump CABG. [9] Similarly, earlier meta-analyses have established a baseline operative mortality risk of approximately 8.5% to 15% for this demographic. [10]

The fact that our mortality rate remained at the lower end of this spectrum suggests that our institutional protocol, specifically the aggressive use of pre-operative dialysis to optimize fluid status and electrolyte balance, was effective in mitigating the acute metabolic risks of uremia. This aligns with findings by Lin et al. [10], who demonstrated that rigorous early dialysis significantly improves surgical outcomes by preventing volume overload and hyperkalemia. [10]

Renal Dysfunction Versus Cardiac Metrics as Predictors

An important finding of our multivariate analysis was that elevated baseline serum creatinine (OR = 3.457; *P* = 0.029) emerged as a significant signal of early mortality. Surprisingly, traditional cardiac metrics, such as preoperative EF and left ventricular end-systolic diameter (LVESD), did not reach significance in the adjusted model.

This phenomenon highlights the dominance of the "uremic milieu" over pump function in this specific population. As discussed earlier, the survival of dialysis patients is often dictated more by the severity of systemic inflammation, metabolic derangement, and frailty (the "non-cardiac" burden) than by anatomical coronary complexity or ventricular function alone. [3] Our data confirms that even minor elevations in creatinine above the patient's baseline signaling uncontrolled azotemia are more lethal than a moderately reduced EF. It is important to note that while we identified baseline creatinine as a predictor, this marker is also closely tied to a patient's nutritional status and muscle mass. In the absence of detailed nutritional metrics, our findings regarding creatinine may partially reflect the complex interplay between metabolic waste clearance and the patient's baseline physical reserve (frailty), both of which are critical in recovering from major cardiac surgery.

Table 3: Postoperative outcomes and early mortality.

Parameter	n (%) or mean ± SD
Early mortality (≤30 days)	7 (7.0%)
Major complications	
Re-exploration for bleeding	11 (11.0%)
Myocardial infarction	4 (4.0%)
Mediastinitis	3 (3.0%)
Low cardiac output syndrome	3 (3.0%)
Other complications	
Wound infection	9 (9.0%)
Arrhythmia (AF/SVT/VT)	10 (10.0%)*
Pulmonary complications†	6 (6.0%)‡
Support and course	
Inotropic support	32 (32.0%)
IABP insertion	10 (10.0%)
Mechanical ventilation duration (hours)	6.22 ± 2.90
ICU stay (days)	2.58 ± 2.37
Hospital stay (days)	8.60 ± 3.98
Postoperative EF (%)	41.65 ± 5.50

AF, atrial fibrillation; SVT, supraventricular tachycardia; VT, ventricular tachycardia; IABP, intra-aortic balloon pump; ICU, intensive care unit; EF, ejection fraction.

*Includes AF (n = 3), SVT (n = 5), VT (n = 2).

†Includes pulmonary congestion and pneumonia.

‡Pulmonary congestion (n = 4), pneumonia (n = 2).

Table 4: Univariate and multivariate logistic regression analysis for predictors of early mortality.

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Baseline S. creatinine	2.31 (1.15–4.62)	0.018	3.46 (1.13–10.58)	0.029
HbA1c	1.10 (0.96–1.26)	0.166	1.05 (0.88–1.25)	0.579
Pre-operative EF (%)	0.91 (0.84–0.98)	0.012	0.96 (0.87–1.06)	0.445
Pre-operative LVEDD	1.80 (0.91–3.56)	0.093	1.26 (0.26–6.17)	0.773
Pre-operative LVESD	2.45 (1.18–5.08)	0.016	2.78 (0.43–18.02)	0.288
Duration of mechanical ventilation	1.47 (1.12–1.92)	0.005	1.33 (0.99–1.78)	0.054

OR, odds ratio; CI, confidence interval; EF, ejection fraction; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter.

Morbidity Profile: Hemorrhage and Infection

The morbidity observed in our cohort reflects the unique pathophysiology of uremia. We noted a re-exploration rate for bleeding of 11.0%, which is notably higher than the 2% to 6% typically expected in standard CABG cohorts. This correlates with recent data indicating that dialysis patients have double the rate of return to the operating room for bleeding compared to non-dialysis controls (5.5% vs. 2.7%). [9] This predisposition is multifactorial, driven by uremic platelet dysfunction and the residual effects of systemic anticoagulation required for dialysis sessions.

Furthermore, the 3.0% incidence of mediastinitis in our study underscores the immunocompromised state of the ESRD patients. With 51% of our cohort suffering from diabetes mellitus, these patients face a synergistic risk for deep sternal wound infections. This aligns with findings by Yamaguchi et al., who reported similar infection rates in diabetic patients receiving arterial grafts, reinforcing the need for strict glycemic control and rigorous sterile technique in this subset. [11]

Postoperative Decline in the Left Ventricular Ejection Fraction

The significant postoperative decline in mean LVEF (left ventricular ejection fraction) (from 50.31% to 41.87%) likely reflects transient myocardial stunning rather than permanent injury. [12] This phenomenon is primarily attributed to the high rate of on-pump procedures (84%), where global ischemia-reperfusion during cardioplegic arrest challenges a myocardium already sensitized by the oxidative stress and microvascular dysfunction of the "uremic milieu." [13] Furthermore, acute alterations in preload and afterload driven by profound perioperative fluid shifts and the initiation of early postoperative dialysis may clinically depress LVEF measurements. In the acute perioperative phase, the initiation of early postoperative dialysis, while necessary for metabolic control, imposes repetitive "myocardial stunning" through transient periods of hypovolemia and ultrafiltration-induced hypotension. This circulatory stress likely exacerbates the global ischemia-reperfusion injury sustained during on-pump CABG, leading to the observed depression in systolic function. Rather than indicating permanent myocyte loss, this decline in EF is more representative of a vulnerable myocardium struggling to maintain stability under the cumulative burden of surgical trauma and the requisite stressors of renal replacement therapy. [13]

Pulmonary Vulnerability and Prolonged Ventilation

The borderline significance of mechanical ventilation duration (P = 0.054) in this exploratory model reflects the inherent pulmonary vulnerability of the ESRD population. Dialysis-dependent patients frequently experience challenges related to fluid overload and pulmonary congestion, which was observed in 4% of this study cohort. These findings suggest that delays in extubation are not merely a consequence of surgical complexity but are fundamentally linked to the metabolic and fluid management hurdles associated with dialysis dependency. [9]

Surgical Strategy: The "LIMA Dilemma"

Perhaps the most distinct aspect of our study was the limited use of the LIMA, which was utilized in only 6.0% of cases. While current guidelines advocate for LIMA use to improve long-term survival, our strategy prioritized preserving vascular access. The "Subclavian Steal" phenomenon, where LIMA flow is diverted to a high-flow upper-extremity arteriovenous fistula, is a documented cause of recurrent myocardial ischemia in ESRD patients. As noted in a 2025 case report by Alsayed, LIMA-coronary steal can precipitate graft failure and angina, necessitating complex interventions. [14] Furthermore, recent analyses suggest that while arterial grafting is superior in the general population, its survival benefit may be attenuated in dialysis patients due to accelerated systemic vascular calcification. [15] Therefore, our vein-graft-heavy strategy (94%) reflects a pragmatic compromise: prioritizing immediate hemodynamic stability and the protection of the patient's dialysis "lifeline" over theoretical long-term graft patency. We must emphasize that its long-term impact on graft patency and patient survival remains unknown. Without longitudinal follow-up data, this strategy should not be viewed as the "optimal" long-term surgical standard, but rather as a patient-centered approach specifically tailored to optimize early outcomes and preserve dialysis "lifelines" in an exceptionally high-risk population.

Limitations

The primary limitations of this study stem from its single-center, observational design, which restricts the generalizability of the findings and introduces potential selection bias. The small sample size (n = 100) and low event rate (7 mortalities) limited the statistical power of the multivariate analysis to establish independent predictors. Crucially, the analysis is restricted to early (30-day) outcomes, preventing any assessment of the long-term impact of the low LIMA utilization rate or the true survival effect of pre-operative factors in the ESRD population, and it also lacks critical confounders such as dialysis duration and detailed nutritional status. Furthermore, the sample size was determined by the number of eligible cases during the study period rather than by a formal power calculation; this may limit the statistical power needed to identify all potential independent predictors of mortality.

CONCLUSIONS

In conclusion, CABG in dialysis-dependent patients can be performed with acceptable mortality (7.0%), comparable to or better than current international standards. The identification of baseline creatinine as the primary predictor of death emphasizes the need for aggressive pre-operative metabolic optimization. While our restricted use of LIMA diverges from standard revascularization guidelines, it highlights a valid, patient-centered approach focused on minimizing operative time and preserving critical vascular access for hemodialysis. Future multi-center studies with larger cohorts are recommended to validate these exploratory predictors and further refine perioperative dialysis protocols.

AUTHORS' CONTRIBUTION

Each author has made a substantial contribution to the present work in one or more areas, including conception, study design, conduct, data collection, analysis, and interpretation. All authors have given final approval of the version to be published, agreed on the journal to which the article has been submitted, and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

None.

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