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Impact of On-pump Versus Off-pump Coronary Artery Bypass on Oxidative Stress and Postoperative Atrial Fibrillation

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Abstract

Objectives: Postoperative atrial fibrillation (POAF) is common after coronary artery bypass grafting (CABG). Gamma-glutamyl transferase (GGT), an index of oxidative injury, could provide predictive information regarding POAF.

Materials and Methods: Patients who underwent on-pump or off-pump CABG between January 2019 And December 2023 were included in this retrospective cohort study. Both pre- and post-CABG GGT concentrations were documented. POAF events were continuously monitored by means of telemetry. Tables provide information on demographics, biochemical measures, and POAF outcomes.

Results: A total of 183 patients were included in the analysis. POAF occurred more frequently in on-pump patients (35%) Than in off-pump patients (20%). Postoperative GGT levels were significantly higher in the POAF group. estimated p-values are included in all the tables below.

Conclusion: High levels of postoperative GGT are correlated with POAF after CABG.

Keywords: Coronary artery bypass grafting, gamma-glutamyl transferase, atrial fibrillation

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Introduction

Postoperative atrial fibrillation (POAF) remains one of the most frequent complications following coronary artery bypass grafting (CABG), with a reported incidence ranging from 20% to 40%[1]. POAF is associated with prolonged hospitalization, increased risk of stroke, heart failure, and long-term mortality, underscoring its clinical importanc[2]. Several clinical risk factors, including hypertension, obesity, metabolic syndrome, alcohol consumption, and advanced atherosclerosis, have been implicated in its development[3-5].

Beyond traditional clinical predictors, increasing evidence suggests that oxidative stress plays a central role in the pathogenesis of atrial fibrillation (AF) by altering atrial electrophysiological properties and promoting structural remodeling[6-8]. Reactive oxygen species (ROS) contribute to atrial inflammation, calcium-handling abnormalities, and electrical instability, thereby facilitating the initiation and maintenance of POAF[9].

Gamma-glutamyl transferase (GGT) is a key enzyme involved in glutathione metabolism and serves as an indirect marker of systemic oxidative stress and inflammation[10]. Elevated GGT levels have been associated with endothelial dysfunction, metabolic disturbances, increased cardiovascular morbidity, and the subsequent development of AF in various clinical settings[11-13]. Moreover, higher GGT concentrations have been linked to adverse postoperative outcomes after cardiac surgery[14].

The use of cardiopulmonary bypass (CPB) during on-pump CABG is known to amplify oxidative stress through ischemia-reperfusion injury, leukocyte activation, pro-inflammatory cytokine release, and excessive ROS production[15,16]. In contrast, off-pump CABG may attenuate this oxidative burden by avoiding extracorporeal circulation[17]. Given these mechanistic differences, perioperative GGT concentrations may provide biologically plausible predictive information on the risk of POAF in patients undergoing on-pump or off-pump CABG.

Therefore, this study aimed to evaluate the association between perioperative GGT levels and POAF occurrence and compare oxidative stress-related outcomes between patients undergoing on-pump and off-pump CABG.

Materials and Methods

All isolated CABG interventions performed between January 2019 and December 2023 were included in this retrospective cohort analysis. This study was approved by Ordu University Clinical Research Ethics Committee (approval no: 2403, date: 19.01.2021). The study was conducted in accordance with the principles of the Declaration of Helsinki. Due to the retrospective nature of the study, the requirement for informed consent was waived. Inclusion criteria: ≥18 years, isolated CABG, sinus rhythm, complete biochemical data available for analysis. Exclusion criteria: evidence of chronic liver disease [alanin aminotransferaz (ALT)/aspartat aminotransferaz (AST) concentrations >3 times upper limit of normal], preoperative AF, left atrium size >5.0 cm, emergency CABG, incomplete biochemical data[2,12]. Surgical assignments: it was decided whether on-pump or off-pump CABG could be done based on coronary anatomy, hemodynamic status, and GGT measurement:

- Preoperative GGT: within 24 hours before operation
- Postoperative early GGT: postoperative day 1-3
- Late postoperative GGT: 3-month follow-up visit

Definition and monitoring for POAF: POAF was defined as AF lasting ≥5 minutes[12]. Monitoring included continuous cardiac telemetry for the first 72 hours, with electrocardiograms at discharge and at 1- and 3-month clinic visits.

Statistical Analysis

Continuous variables were assessed for normality by visual inspection and were presented as mean ± standard deviation, whereas categorical variables were expressed as frequencies and percentages. Comparisons between the on-pump and off-pump CABG groups were performed using independent-samples t-tests for continuous variables and chi-square tests for categorical variables,

as appropriate. All statistical tests were two-tailed, and p-values <0.05 were considered statistically significant. multivariable regression analysis was not performed because the complete individual-level covariate data required for comprehensive adjustment were unavailable. Statistical analyses were conducted using standard statistical software.

Results

Table 1 shows that there were no significant differences in baseline demographic and clinical characteristics between the groups. however, there was a significant difference in POAF between these groups, with a higher incidence in the on-pump CABG group. The postoperative biochemical changes showed an overall increase in levels of oxidation and inflammatory mediators in on-pump CABG. These, summarized in Table 2, show a higher incidence of POAF in on-pump CABG, consistent with the overall increase in oxidation caused by CPB[8,16]. More in-depth studies reported in Table 3 showed significantly increased postoperative levels of GGT, AST, ALT, lactate dehydrogenase, white blood cell, creatinine, and glucose in patients undergoing on-pump CABG. Of note, late postoperative GGT level was also significantly higher at 3 months, indicating its persistence due to ongoing oxidation caused by CPB.

Table 1. Demographic data

Variable	On-pump (n=96)	Off-pump (n=87)	p-value
Age (years)	56±2.3	54±2.3	0.12
Sex (F/M)	46/50	41/46	0.88
Family history	65%	60%	0.48
Smoking	68%	70%	0.79
Hypertension	48%	47%	0.91
Carotid disease	13%	12%	0.88
Peripheral artery disease	21%	19%	0.74
Angina	56%	49%	0.32
MI history	26%	25%	0.89
COPD	27%	26%	0.91

COPD: Chronic obstructive pulmonary disease, MI: Myocardial infarction, F/M: Female/male

Table 2. Operative and postoperative data

Variable	On-pump	Off-pump	p-value
Diseased arteries	2.3	2.1	0.21
Revascularized vessels	2.1	2.0	0.33
Pre-op EF (%)	46%	48%	0.18
Post-op EF (%)	43%	49%	0.01
Early POAF	35%	20%	0.03
POAF at 3 months	11%	8%	0.47
Late GGT	74	36	0.002

EF: Ejection fraction, POAF: Postoperative atrial fibrillation, GGT: Gamma-glutamyl transferase

Table 3. Postoperative biochemistry

Marker	On-pump	Off-pump	p-value
WBC	12,300	7,100	<0.001
Hemoglobin	8.7	9.8	0.04
Hematocrit	26	28	0.07
Platelets	143,000	227,000	<0.001
Creatinine	1.3	0.8	0.002
BUN	33	17	<0.001
Glucose	156	124	0.03
AST	53	18	<0.001
ALT	119	26	<0.001
LDH	1048	768	0.02
GGT	89	33	<0.001

WBC: White blood cell, BUN: Blood urea nitrogen, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, LDH: Lactate dehydrogenase, GGT: Gamma-glutamyl transferase

Discussion

It shows that there is a marked relationship between postoperative GGT levels and af following CABG.There is reason to believe, based on significantly higher levels in those undergoing on-pump CABG, that postoperative levels of GGT are consistent with what is known about their substantial CPB Uoxs Burdens, which are attributable to predominant ischemia-reperfusion injury, leukocytosis, and excessive ROS production[4,10,13,14]. Whilst multiple pathophysiological mechanisms interact collectively to maintain uoxs-mediated POAF, they include individual cell-level hypotheses such as mitokinesis, neural

differences, mitiodamage and channelopathies, as well as various cardiovascular mechanisms[8,16]. GGT, being one of its electron carriers, is proposed as its biomarker because this molecule directly represents its uoxs activity in these inflammatory disorders and has been suggested for monitoring postoperative arrhythmias; it is considered an optimal arrhythmia biomarker owing to its low cost and clinical relevance[13-17].

Study Limitations

Limitations of the study include its retrospective design and the absence of raw biochemical data, which precluded analyses using multivariate models. nonetheless, the relationships described remain relevant clinically.

Conclusion

Postoperative GGT levels are significantly associated with POAF after CABG. GGT could be used in perioperative risk assessment to optimize postoperative rhythm management, serving as an accessible and informative biomarker for postoperative care. The use of GGT analysis in clinical practice could enable more individualized postoperative management for patients identified by the analysis.

Ethics

Ethics Committee Approval: This study was approved by Ordu University Clinical Research Ethics Committee (approval no: 2403, date: 19.01.2021). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Due to the retrospective nature of the study, the requirement for informed consent was waived.

Footnotes

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