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Postoperative Arrhythmia after Total Arterial Coronary Artery Bypass Grafting

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Abstract

Background: Atrial fibrillation (AF) is the most prevalent arrhythmia occurring after cardiac surgery. The occurrence of postoperative AF (POAF) significantly affects patient outcomes, leading to increased morbidity, mortality, and hospital readmission rates. The incidence of POAF following total arterial coronary artery bypass grafting remains a subject of ongoing debate. This study seeks to evaluate the occurrence of early postoperative arrhythmias in patients undergoing total arterial revascularization.

Methods: We studied a cohort of 50 patients who underwent total arterial revascularization at the Cardiothoracic Surgery Department of Benha University Hospitals between October 2023 and October 2024. Data were collected preoperatively and postoperatively, encompassing demographic information, laboratory results, and both intraoperative and postoperative parameters.

Results: The average age of the study population was 52.5 years, with a predominance of male patients. The incidence of postoperative arrhythmias was recorded as follows: 6% for self-contained AF, 6% for uncontrolled AF, 2% for ventricular fibrillation, and 4% for premature ventricular contractions. The mean duration of bypass was 154.9 minutes, and the average length of stay in the intensive care unit (ICU) was 2.1 days. Postoperative complications included wound infections in 28% of patients, and the mortality rate was 4%.

Conclusions: Early postoperative arrhythmias pose a significant concern following total arterial revascularization. Identifying and managing risk factors associated with these arrhythmias could enhance patient outcomes, decrease complications, and ultimately contribute to improved survival and quality of life for individuals undergoing cardiac surgery.

KEYWORDS

CABG; Arrhythmia; Total Arterial Conduits; Arterial Revascularization; Atrial Fibrillation

Introduction

Atrial fibrillation (AF) is the most prevalent arrhythmia following cardiac surgery, affecting 15–40% of cases [1]. Its occurrence is more common in patients undergoing valve surgery or a combination of valve and coronary artery bypass grafting (CABG) compared to those undergoing CABG alone. While postoperative AF (POAF) is typically self-limiting, uncontrolled cases necessitate additional medical therapy, which can prolong hospital stays and increase healthcare costs [1]. Supraventricular arrhythmias, particularly AF and atrial flutter (AFlu), are the predominant rhythm disorders observed after

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cardiac surgery. Initially regarded as benign and transient, growing evidence indicates that POAF contributes to heightened morbidity and mortality [2]. The incidence rates are approximately 25–40% after CABG, 50–60% post-valve surgery, and 62% in combined CABG-valve procedures, with heart transplant patients exhibiting the lowest rates. Additionally, POAF prevalence increases with advancing patient age [2].

POAF typically manifests on days 2 to 3 following surgery, with 70% of cases occurring within the first four days. Recurrences are most frequently observed on postoperative day three, with 60% of these recurrences happening within two days of the initial episode [3]. POAF remains a leading cause of hospital readmission. Reported incidence rates of POAF vary significantly (10–65%), influenced by differences in patient demographics, criteria for AF classification, types of surgical operations, and methods of detection [3].

Risk factors for POAF include advanced age, male sex, a history of AF, diabetes, chronic obstructive pulmonary disease (COPD), chronic renal failure, low ejection fraction, left atrial enlargement, rheumatic heart disease, and hypertension. These variables may be linked to atrial fibrosis and the dispersion of refractoriness. Some studies suggest a higher susceptibility to POAF among males, while others indicate no gender differences [4].

Most cases of POAF are resolved within 24 hours after surgery. Management begins with addressing underlying predispositions, such as anemia, hypoxia, and electrolyte imbalances. For patients who are hemodynamically unstable, electrical cardioversion or administration of amiodarone is recommended, with direct current shock indicated for severe symptoms or difficult rate control [5].

Despite extensive research on POAF, its prevalence in specific patient populations, such as those undergoing CABG with total arterial revascularization, has not been thoroughly examined. Therefore, this study aims to evaluate the incidence of early postoperative arrhythmias following total arterial revascularization.

Patients and Methods

Study Design

This prospective cohort study was conducted in the Cardiothoracic Surgery Department at Benha University Hospitals from October 2023 to October 2024. The study included 50 patients who underwent total artery coronary artery bypass grafting (CABG). Approval was obtained from the Ethical Scientific Committee at Benha University Hospitals. Informed consent was secured from all patients after explaining the study's objectives, procedures, risks, and benefits.

Patients

The study focused on patients who underwent isolated total arterial revascularization during the specified period. Exclusion criteria included individuals with documented preoperative arrhythmias of any type, a history of valvular diseases, prior open-heart surgeries, or those with implantable defibrillators or pacemakers. Additionally, patients who had undergone off-pump CABG procedures were excluded.

Data Collection

All participants received comprehensive care that included a complete medical history and physical examination, detailing age, gender, residence, occupation, socioeconomic status, education level, and lifestyle habits. Comorbidities—such as diabetes, hypertension, and thyroid disease—were documented. Clinical parameters monitored included heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, and oxygen saturation through non-invasive methods.

Laboratory investigations encompassed complete blood count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), prothrombin time (PT), partial thromboplastin time (PTT), international normalized ratio (INR), sodium, potassium, arterial blood gases (ABG), renal function tests (urea and creatinine), and fasting blood sugar.

Each patient underwent a 12-lead electrocardiogram, chest X-ray, echocardiography, and coronary angiography.

Table 1: Demographic data of the studied patients. Data were presented as numbers (%) and mean (SD)

	(n= 50)
Age (years) Mean ± SD	52.5 ± 8.96
DM	32 (64%)
HTN	30 (60%)
Thyroid disease	0
Smoking	29 (58%)
Male	39 (78%)
Hemoglobin (mg/dL)	12 ± 1.31
Platelets (/mcL)	278.7 ± 90.11
Total leukocyte count (*10^9/L)	7.2 ± 2.16
Urea (mg/dL)	40.4 ± 18.11
Creatinine(mg/dL)	1.1 ± 0.26
INR	1 ± 0.09
EF (%)	0.5 ± 0.08
RWMA	49 (98%)

n = Sample size, **DM =** Diabetes Mellitus, **HTN =** Hypertension, **SD =** Standard Deviation, **mg/dL =** Milligrams per Deciliter, **/mcL =** Per Microliter, ***10^9/L =** Per Billion per Liter (Total Leukocyte Count unit), **INR =** International Normalized Ratio, **EF (%) =** Ejection Fraction (Percentage), **RWMA =** Regional Wall Motion Abnormalities

Intraoperative data included cross-clamp and total bypass times, the type and dosage of cardioplegia solution used, bypass temperature, the number and type of grafts, and involvement of the right coronary or posterior descending artery. Postoperative data were collected regarding mechanical support (such as ventilator use and intra-aortic balloon pump), duration of ICU stay, inotropic support (including adrenaline and noradrenaline), blood gases, serum potassium, lactate levels, blood glucose, and chest X-ray findings. Postoperative electrocardiograms were monitored for ischemic changes and arrhythmias, with any arrhythmia lasting over five minutes or requiring intervention duly recorded. Complications such as wound infections, pleural collections, phrenic nerve injuries, pericardial effusion, lung collapses, bleeding, and thromboembolic events (including acute limb ischemia, transient ischemic attacks, and strokes) were also documented.

Statistical analysis

Statistical analysis was performed using SPSS v26 (IBM Inc., Chicago, IL, USA). The mean and standard deviation (SD) of quantitative parametric variables were calculated. Quantitative variables were presented as frequency and percentage (%).

Results

This study involved 50 patients who underwent total arterial revascularization surgeries. The ages of participants ranged from 36 to 70 years, with a mean (±SD) age of 52.5 ± 8.96 years. The cohort consisted of 39 males (78%) and 11 females (22%). Comorbid conditions included diabetes mellitus (DM) in 32 patients (64%) and hypertension in 30 patients (60%). No patients had a history of thyroid disease, and 29 patients (58%) were smokers. Laboratory values were as follows: hemoglobin levels ranged from 9.7 to 15 mg/dL (mean 12 ± 1.31), platelet counts spanned 112 to 450 /mcL (mean 278.7 ± 90.11), total leukocyte counts (TLC) varied from 4.3 to 15.4 ×10^9/L (mean 7.2 ± 2.16), urea levels ranged from 21 to 121 mg/dL (mean 40.4 ± 18.11), creatinine levels ranged from 0.8 to 2.1 mg/dL (mean 1.1 ± 0.26), and International Normalized Ratio (INR) values ranged from 0.9 to 1.3 (mean 1 ± 0.09). The ejection fraction (EF) ranged from 0.4 to 0.7%, with a mean (±SD) of 0.5 ± 0.08%. Regarding regional wall motion abnormalities (RWMA), 49 patients (98%) exhibited hypokinesia, while one patient (2%) showed no RWMA (see Table 1).

Table 2: Pre-operative ECG, and cardiac catheter data of the studied patients. Data were presented as n (%)

	n= 50
Anterior lateral STEMI	29 (58%)
Anterior lateral inferior STEMI	21 (42%)
LAD, CXR and RCA	19 (38%)
LAD	6 (12%)
LAD and RCA	5 (10%)
LAD and CXR	20 (40%)

n= Sample size, **STEMI=** ST-Elevation Myocardial Infarction, **AF=** Atrial Fibrillation, **VF=** Ventricular Fibrillation, **PVCs=** Premature Ventricular Contractions, **LAD=** left anterior descending, **CXR=** Chest X-Ray, **RCA=** Right coronary artery

Pre-operative electrocardiograms (ECGs) revealed anterolateral ST-elevation myocardial

infarction (STEMI) in 29 patients (58%) and anterior lateral inferior STEMI in 21 patients (42%) (see Table 2).

The duration of bypass surgery ranged from 71 to 280 minutes, with a mean (±SD) of 154.9 ± 36.95 minutes. Cross-clamp times varied from 29 to 190 minutes, with a mean (±SD) of 113.3 ± 30.49 minutes. During the weaning phase from bypass, 22 patients (44%) required direct current (DC) shock, 27 patients (54%) underwent smooth weaning, and one patient (2%) experienced multiple DC shocks. Ventilation time varied from 6 to 72 hours, with a mean (±SD) of 9.3 ± 9.47 hours. ICU stays ranged from 1 to 3 days, with a mean (±SD) of 2.1 ± 0.57 days, while the total hospital stay varied from 3 to 7 days, averaging (±SD) 5.1 ± 1.18 days (see Table 3).

Table 3: Operative and post-operative data of the studied patients. Data were presented as number (%) and mean (SD)

	n= 50
Cardiopulmonary bypass time (min)	154.9 ± 36.95
Cross-clamp time (min)	113.3 ± 30.49
Coming off bypass	
DC shock	22 (44%)
Smooth	27 (54%)
DC shock & coming smooth	1 (2%)
Ventilation time (h)	9.3 ± 9.47
ICU stay (days)	2.1 ± 0.57
Hospital stay (days)	5.1 ± 1.18

n = Sample size, **SD** = Standard Deviation, **DC shock** = Direct Current Shock, **ICU** = Intensive Care Unit

Complications observed included wound infections in 14 patients (28%), bleeding in one patient (2%), the need for re-exploration due to bleeding in one patient (2%), and re-intubation in three patients (6%). Hospital mortality was recorded in two patients (4%) (see Table 4).

According to postoperative ECG findings, three patients (6%) demonstrated self-controlled AF, three patients (6%) exhibited uncontrolled AF, one patient (2%) developed ventricular fibrillation (VF), 41 patients (82%) maintained a normal sinus rhythm, and two patients (4%) presented with premature ventricular contractions (PVCs). Table 5

Table 4: Post-operative complications and outcome of the studied patients

	n= 50
Wound infection	14 (28%)
Bleeding	1 (2%)
Re-exploration	1 (2%)
Re-intubation	3 (6%)
Mortality	2 (4%)

Table 5: The incidence of postoperative arrhythmia

	n= 50
AF self-controlled	3 (6%)
Uncontrolled AF	3 (6%)
Developed VF	1 (2%)
Normal sinus rhythm	41 (82%)
PVCs	2 (4%)

Discussion

Cardiovascular disease is the leading cause of death, with percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) being common procedures for managing multi-vessel and left main disease [6]. Postoperative arrhythmias, particularly atrial tachyarrhythmias, are significant complications that impact both morbidity and mortality. The severity of these arrhythmias depends on their duration, ventricular response, and the presence of comorbidities, with younger patients generally tolerating arrhythmias better [7]. Management strategies include correcting predisposing factors and providing treatment for severe cases [8]. New-onset postoperative atrial fibrillation (POAF) is common after CABG and is associated with both short-term and long-term risks [9]. This study, conducted at Benha University Hospital from October 2023 to 2024, aims to assess early arrhythmias in patients undergoing total arterial revascularization. It included 50 patients, with preoperative, intraoperative, and postoperative data collected, including arrhythmia monitoring via 12-lead ECG.

In the current study, a significant number of patients had diabetes mellitus, which aligns with findings from Raza et al., who investigated

temporal trends of diabetes and cardiovascular risk factors among CABG patients. Their study, conducted from January 1972 to January 2011, found that the number of diabetics undergoing CABG increased over time, with a follow-up period of 12 years. They compared in-hospital outcomes, resource utilization, and long-term survival between diabetic and non-diabetic patients after CABG [10]. Furthermore, Nomali et al. evaluated the correlation between type 2 diabetes mellitus (T2DM) and in-hospital major adverse cardiac and cerebrovascular events (MACCEs) and postoperative complications in patients who underwent on-pump isolated CABG. Their retrospective cohort study utilized data from two cardiac facilities in Golestan province (North of Iran) between 2007 and 2016, revealing that diabetic patients exhibited a higher incidence of postoperative arrhythmias compared to non-diabetic patients [11].

Nomali et al. also analyzed postoperative complications in two groups and found that diabetes mellitus is a predictor of postoperative arrhythmias, increasing the risk, although no direct association was established between diabetes and POAF [12]. Diabetic patients generally demonstrate a higher rate of arrhythmias [13], but studies present contradictory findings. Ismail and colleagues identified diabetes as an independent factor for POAF in CABG patients [14], while Mangi et al. reported that post-CABG patients with POAF had higher rates of diabetes [15]. Conversely, Woldendorp et al.'s meta-analysis found no significant difference in diabetes prevalence between patients with POAF and those with normal sinus rhythm after CABG [16].

In the present study, the duration of bypass surgery varied significantly, which is consistent with findings from Navia et al. Their investigation examined the use of bilateral internal thoracic arteries in triple-vessel disease for total arterial off-pump coronary artery bypass grafting (OPCABG). In a retrospective review of multivessel CABG patients, Navia et al. reported an average operation time of approximately 210 minutes, comparable to the mean duration observed in our study [17]. Additionally, the current study recorded ICU stays ranging from 1 to 3 days, with a mean duration consistent with findings from Zarrizi et al., who aimed to identify predictors of ICU length of stay (LOS) after CABG and develop a risk scoring system. Zarrizi et al.'s retrospective review of post-CABG patients revealed a mean ICU LOS comparable to our findings [18].

Despite its beneficial effects in managing the symptoms and indicators of coronary artery disease, CABG presents numerous short- and long-term complications. Consequently, all patients undergoing CABG must be treated in the intensive care unit (ICU). The length of stay (LOS) in the ICU following CABG depends on individual patient characteristics, pre- and intraoperative care, complications occurring during surgery, and hospital policies and regulations [19].

In the current study, postoperative electrocardiogram (ECG) findings included patients with self-controlled atrial fibrillation (AF), uncontrolled AF, ventricular fibrillation (VF), normal sinus rhythm, and premature ventricular contractions (PVCs). Maisel et al. reviewed the epidemiology, mechanisms, complications, predictors, prevention, and treatment of AF after cardiac surgery, noting that AF commonly occurs postoperatively, typically on the second or third day [20]. In the absence of vagal modulation, Pavri et al. conducted a study examining the duration and prognostic significance of atrial arrhythmias in denervated transplanted hearts. This investigation encompassed continuous electrocardiographic tracings and telemetry from 88 orthotopic heart transplantations in 85 patients. The results indicated that at least one atrial arrhythmia developed in half of the recipients, including supraventricular tachycardia, ectopic atrial tachycardia, atrial flutter (AFlu), and AF [21].

The discrepancy in postoperative arrhythmia rates between the present study and those reported by Maisel et al. and Pavri et al. may be attributed to differences in patient populations, surgical techniques, and monitoring protocols. Our study specifically focused on patients undergoing total arterial revascularization, which may differ inherently in arrhythmia risk compared to the broader cardiac surgeries analyzed by

Maisel et al. or the unique population of heart transplant recipients studied by Pavri et al. [22]. Advancements in perioperative care, such as refined anesthesia protocols, improved electrolyte management, and enhanced postoperative monitoring, could explain the lower rates of arrhythmias observed in our cohort. The reduced occurrence of AF in our study, compared to the range noted by Maisel et al., suggests that these modern interventions have an impact on arrhythmia prevention. Furthermore, the use of continuous telemetry and specific population characteristics in Pavri et al.'s study likely contributed to the higher detection of arrhythmias in their transplanted heart patients [23].

Postoperative atrial fibrillation and AFlu most frequently occur within the first few days after surgery, peaking on postoperative days 2 and 3 [24]. Data from a prospective multicenter study of 4,657 patients who underwent surgery indicated that the majority of initial episodes of AF occurred by day two, while most recurrent episodes were noted by day three. Moreover, over 40% of patients with AF experienced multiple episodes [25].

AF is typically self-limiting in patients with POAF who have no prior history of atrial arrhythmias. Most patients will convert to sinus rhythm within a few hours, and the majority will do so within 24 hours. Most patients return to sinus rhythm within six to eight weeks after surgery, with the mean duration of AF typically being 11 to 12 hours. A previous study indicated that the number of patients who remained in AF six weeks after undergoing CABG was minimal [26]. The contributions of re-entrant and focal mechanisms to postoperative atrial arrhythmias remain unclear. Besides common risk factors, several electrophysiologic parameters, such as atrial refractoriness dispersion and atrial conduction velocity, may contribute to the development of AF. Nonuniform atrial conduction, peaking on postoperative days two to three, aligns with the highest risk for AF. AF following CABG is associated with increased connexin-40 expression and distribution, which may alter atrial myocardial conductivity. Additionally, preoperative increases in P wave duration on ECG have been identified as potential risk factors for atrial tachyarrhythmias [27].

Limitations

This research has several limitations, including a single-center design that may restrict generalizability, a short follow-up period, and a limited sample size.

Conclusion

Early postoperative arrhythmias pose a significant concern following total arterial revascularization. Identifying and managing risk factors associated with these arrhythmias could enhance patient outcomes, decrease complications, and ultimately contribute to improved survival and quality of life for individuals undergoing cardiac surgery.

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