Patterns of Atrial Fibrillation After Coronary Artery Bypass Surgery

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Background: Atrial fibrillation (AF) is the most common arrhythmia occurring in patients after coronary artery bypass surgery (CABG). The purpose of this study was to determine whether AF characteristics were independently associated with postoperative length of stay (LOS).

Methods: Two hundred ninety consecutive post-CABG patients were examined through a detailed chart review. Baseline, intraoperative, and postoperative variables and the characteristics of AF were recorded. AF episodes were divided into single episodes lasting less than 24 hours (short-lived AF) and recurrent or prolonged ≥ 24 hours of AF (recurrent/prolonged AF).

Results: AF occurred in 94 (32.4%) patients. Twenty-six (27.7%) of AF patients had short-lived AF, and 68 (72.3%) of AF patients had recurrent/prolonged AF. Patients with recurrent/prolonged AF were older ($P < 0.001$) and more likely to have a history of prior AF ($P < 0.001$) relative to the other groups. Short-lived AF did not prolong LOS (7.2 ± 2.1 days) relative to patients without AF (7.5 ± 3.9 days), whereas recurrent/prolonged AF significantly prolonged LOS (10.4 ± 6.1 days, $P < 0.001$). Multivariate analysis identified postoperative complications, recurrent/prolonged AF, age, and digoxin use as independent predictors of LOS. Recurrent/prolonged AF contributed an additional 1.1 days to LOS after adjusting for baseline clinical differences.

Conclusions: There are heterogeneous patterns of AF after cardiac surgery. A substantial minority of AF is short-lived and isolated with no impact on LOS; however, recurrent or prolonged AF significantly affects LOS.

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atrial fibrillation; cardiac surgery; coronary artery bypass surgery; length of stay

Atrial fibrillation (AF) is the most common sustained arrhythmia following cardiac surgery, and represents a major cause of morbidity and increased utilization of health care resources.¹ Although there is an abundance of literature on the prevalence, risk factors, and management of AF after cardiac surgery, there is scarce data regarding the patterns of postoperative AF. Previous studies have typically grouped all presentations of AF into a single category regardless of duration, recurrences, hemodynamics, and need for cardioversion.¹⁻⁶ Some studies required postoperative AF to last as little as 30 seconds to qualify as an endpoint⁷ while other studies required at least 30 minutes of AF.⁸ Although postoperative AF can be short-lived and without sequelae, a number of patients experience recurrences or remain in AF at the time of

discharge from the hospital despite aggressive attempts at treating this arrhythmia. The approach to a patient with a single, asymptomatic, self-limited episode of AF might differ considerably from that of a patient who has recurrent or persistent AF.

We hypothesized that all postoperative AF is not alike. The objective of this study was to describe the patterns of postoperative AF, and to determine which group of patients may warrant early or more aggressive treatment with antiarrhythmic agents or anticoagulation.

METHODS

Case Selection

We performed a retrospective analysis through a detailed medical record chart review on 290

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consecutive patients who underwent coronary artery bypass surgery (CABG) at our institution over a 14-month period. Patients were identified through a department log of cardiac surgery cases during this time period. Patients who had concomitant valve replacement were also included in the analysis. All patients underwent conventional "on-pump" CABG. Patients who were in normal sinus rhythm (NSR) at the time of the procedure were included in this database. Charts with incomplete or missing recordings were excluded. The primary focus of this study was the development of postoperative AF, with particular interest on the patterns of individual AF episodes.

Cardiac surgery patients were routinely monitored by telemetry for at least 2 or 3 days after surgery, including 1 or 2 days in the intensive care unit, and 1 or 2 more days in the step-down unit. After this, telemetry was discontinued at the discretion of the attending cardiologist. Telemetry was reinstituted for each episode of AF. In most cases, initial episodes of AF were identified by telemetry monitoring and a hard copy of the rhythm strip and/or the 12-lead ECG was placed in the patient's chart. After reviewing the ECG or telemetry strip, physicians and nurses would then document the arrhythmia in the progress or nursing notes. Every hour telemetry strips were reviewed and the rhythm recorded in the patient's bedside. There was no formal protocol for prophylactic use of β -adrenergic blocking agents or antiarrhythmic drugs for AF prevention, and therapy was given at the discretion of the attending cardiologist.

Data Collection

Baseline clinical variables, intraoperative data, and postoperative course including the development of postoperative AF or any serious postoperative event were recorded after careful chart review. Postoperative data collection focused on the occurrence and timing of AF, the duration of the initial episode, as well as the number and duration of subsequent episodes. Our reviewers examined all 12-lead ECGs, telemetry strips, bedside recordings, nursing and progress notes from the patient's chart to identify, and verify each AF episode. We defined postoperative AF as any episode lasting over 15 minutes. After recording AF episodes in individual patients, we then proceeded to divide patients with AF into two groups. The first group included patients with a single episode of AF lasting

<24 hours (Short-lived AF). The second group included patients with prolonged (≥ 24 hours) or recurrent AF (prolonged/recurrent AF).

Statistical Analysis

Continuous variables were expressed as mean $\pm$ SD and analyzed using unpaired 2-tailed Student's *t*-test. Categorical variables were summarized as percentage and compared by chi-square analysis. The 95% CI was reported where appropriate. Univariate analysis was performed on all variables, and those with a *P* value of less than 0.1 were included in the multivariate logistic regression analysis. Variables were selected in a step-wise forward selection manner with entry and retention chosen at *P* < 0.05. SPSS Version 10.0 computer software was used for statistical analysis.

RESULTS

Patterns of AF

Among 290 patients who underwent cardiac surgery, 94 (32.4%) developed AF. AF occurred 2.3 ± 1.2 days after surgery, with 64% of AF occurring by the second postoperative day, and 89% occurring by postoperative day 3. There was tremendous variation in the duration of the initial AF episode (26.1 ± 51 hours, range 15 minutes to 288 hours). The median duration of postoperative AF was 7 hours; 69 (73%) patients had an initial episode lasting less than 24 hours and 25 (27%) greater than 24 hours.

Forty-two (45%) patients experienced a single AF episode and 26 (28%) experienced a single episode lasting less than 24 hours (short-lived AF). There were 68 (72%) patients who had either recurrent episodes of AF (*n* = 52; 55%) and/or episodes lasting ≥ 24 hours (*n* = 26; 28%) (recurrent/prolonged AF). The average duration of the initial AF episode for patients with short-lived AF and recurrent/prolonged AF was 4.3 ± 3.0 hours and 34.4 ± 58.3 hours, respectively (*P* = 0.01). The average number of recurrences was 3.2 ± 2.4 episodes. Nine (10%) patients were in AF at the time of discharge from the hospital.

Baseline, Intraoperative and Postoperative Variables

Table 1 depicts the baseline variables, and intraoperative and postoperative course for the group

Table 1. Baseline, Intraoperative, and Postoperative Variables

Demographics	AF (n = 94)	No AF (n = 196)	P Value
Age (years)	67.0 ± 9.2	61.7 ± 9.8	<0.001
Male gender	66 (70.2%)	129 (65.8%)	NS
Smoking	62 (66.0%)	113 (57.7%)	NS
Hypertension	65 (69.1%)	140 (71.4%)	NS
Diabetes	34 (36.2%)	81 (41.3%)	NS
Chronic lung disease	13 (13.8%)	23 (11.7%)	NS
ESRD	6 (6.4%)	4 (2.0%)	NS
Prior stroke	7 (7.4%)	14 (7.1%)	NS
Prior MI	38 (40.4%)	71 (36.2%)	NS
Prior CABG	8 (8.5%)	14 (7.1%)	NS
Prior AF/Afl	17 (18.1%)	3 (1.5%)	<0.001
LVEF (%)	42.6 ± 13.0	45.8 ± 13.0	0.052
Preoperative β -blocker	55 (58.5%)	116 (59.2%)	NS
Preoperative digoxin	13 (13.8%)	12 (6.1%)	0.029
Number of grafts	3.22 ± 1.02	3.38 ± 1.83	NS
Valve surgery	3 (3.2%)	1 (0.5%)	NS
Postoperative complication	11 (11.7%)	32 (16.3%)	NS

ESRD = end staged renal disease; MI = myocardial infarction; CABG = coronary artery bypass graft surgery; AF = atrial fibrillation; Afl = atrial flutter; LVEF = left ventricular ejection fraction.

of patients with AF and for those who remained in NSR throughout the postoperative period, and Table 2 depicts these variables for patients with no AF, short-lived AF, and recurrent/prolonged AF. Patients who developed AF were older (67.0 ± 9.2

years vs 61.7 ± 9.8 years, $P < 0.001$) and were significantly more likely to have a prior history of AF (18.1% vs 1.5%, $P < 0.001$). Digoxin use prior to surgery was also significantly higher in the patients who developed postoperative AF compared with

Table 2. Baseline, Intraoperative, and Postoperative Variables for the Individual Types of AF

Characteristics	No AF (n = 196)	Short-Lived AF (n = 26)	Recurrent/ Prolonged AF (n = 68)	P Value	P Value No AF vs Short- Lived AF	P Value No AF vs Recurrent/ Prolonged AF
Age (years)	61.7 ± 9.8	65.3 ± 9.5	67.6 ± 9.1	<0.001	0.08	<0.001
Male gender	129 (65.8%)	16 (61.5%)	50 (73.5%)	NS	NS	NS
Smoking	113 (57.7%)	16 (61.5%)	46 (67.6%)	NS	NS	NS
Hypertension	140 (71.4%)	19 (73.1%)	46 (67.6%)	NS	NS	NS
Diabetes	81 (41.3%)	10 (38.5%)	24 (35.3%)	NS	NS	NS
Chronic lung disease	23 (1.7%)	5 (19.2%)	8 (11.8%)	NS	NS	NS
ESRD	4 (2.0%)	3 (11.5%)	3 (4.4%)	0.039	0.009	NS
Prior stroke	14 (7.1%)	2 (7.7%)	5 (7.4%)	NS	NS	NS
Prior MI	71 (36.2%)	10 (38.5%)	28 (41.2%)	NS	NS	NS
Prior CABG	14 (7.1%)	2 (7.7%)	6 (8.8%)	NS	NS	NS
Prior AF/Afl	3 (1.5%)	5 (19.2%)	12 (17.6%)	<0.001	<0.001	<0.001
LVEF (%)	45.8 ± 13.0	38.9 ± 12.0	44.0 ± 13.0	0.035	0.011	NS
Preoperative β -blocker	116 (59.2%)	17 (65.4%)	38 (55.9%)	NS	NS	NS
Preoperative digoxin	12 (6.1%)	2 (7.7%)	11 (16.2%)	0.039	NS	0.01
Number of grafts	3.2 ± 1.0	3.9 ± 3.1	3.2 ± 1.0	NS	NS	NS
Valve surgery	1 (0.5%)	0 (0%)	3 (4.4%)	0.049	NS	0.023
Postoperative complication	32 (16.3%)	2 (7.7%)	9 (13.2%)	NS	NS	NS

ESRD = end staged renal disease; MI = myocardial infarction; CABG = coronary artery bypass graft surgery; AF = atrial fibrillation; Afl = atrial flutter; LVEF = left ventricular ejection fraction.

the patients who remained in NSR (13.8% vs 6.1%, $P = 0.029$). Patients with AF had a trend toward a lower left ventricular ejection fraction than patients in NSR ($42.6 \pm 13.0\%$ vs $45.8 \pm 13.0\%$, $P = 0.052$). There were no significant differences in intraoperative or postoperative variables between the groups, including the type of surgical procedure performed, the number of vessels bypassed, and the occurrence of postoperative complications. There were a total of three perioperative deaths (1%). Multivariate analysis on the parameters listed in Table 1 demonstrated that advanced age and a prior history of AF were the only independent predictors of postoperative AF ($P < 0.001$).

Patients with recurrent/prolonged AF tended to be older than patients with no AF were more likely to have a history of prior AF and to have undergone valve replacement surgery. Patients with short-lived AF had lower ejection fractions, and were more likely to have a history of prior AF, or renal disease when compared to patients with no AF. There were no notable differences in other intraoperative or postoperative variables among the AF groups, including the number of vessels bypassed, and the occurrence of postoperative complications. Multivariate analysis on the parameters listed in Table 2 demonstrated that age and prior history of AF were the only independent predictors of recurrent/prolonged AF ($P < 0.001$).

Therapy Instituted in the Postoperative Period

The administration of β -adrenergic blocking agents early after surgery (on or before postoperative day 2) was similar for patients with no AF (44%), short-lived AF (54%), and recurrent/pro-

longed AF (50%). When AF developed, β -adrenergic blocking agents were used less often for rate control in the group of patients with short-lived AF than patients with recurrent/prolonged AF (Table 3). During the first 24 hours of AF, there was a trend toward less frequent use of antiarrhythmic medications in the group of patients with short-lived AF, (4% vs 15%, $P = 0.14$). Over the entire hospital stay, patients with short-lived AF were also less likely to be treated with IV heparin and antiarrhythmic therapy and were less frequently discharged on warfarin therapy (Table 3). Cardioversion was infrequently employed, but equally used among the two groups. Among the patients cardioverted, 3 (38%) had recurrent AF following cardioversion.

Length of Stay

The postoperative length of stay (LOS) was significantly longer for patients with AF than patients in NSR (9.5 ± 5.5 days vs 7.5 ± 3.9 days, $P < 0.0001$). However, patients with short-lived AF had similar LOS to patients without AF (7.2 ± 2.1 days vs 7.5 ± 3.9 days, $P = 0.6$), while recurrent/prolonged AF significantly prolonged LOS when compared with those patients with no AF (10.4 ± 6.1 days vs 7.5 ± 3.9 days, $P < 0.0001$) (Fig. 1). Multivariate analysis identified postoperative complications, recurrent/prolonged AF, age, and digoxin as independent predictors of LOS (Table 4). After adjusting for other confounding variables, recurrent/prolonged AF contributed an additional 1.1 ± 0.3 days to LOS.

DISCUSSION

To our knowledge, this is the first report to differentiate AF as short-lived or recurrent/prolonged,

Table 3. Therapy Instituted in the Postoperative Period

	Short-lived AF (n = 26)	Recurrent/Prolonged AF (n = 68)	P Value
Early BB therapy (on or before POD 2)	53.8%	50.0%	NS
BB therapy to treat initial AF	6 (23%)	33 (48%)	0.02
CCB therapy to treat initial AF	5 (19%)	21 (31%)	NS
Digoxin therapy to treat initial AF	14 (54%)	42 (62%)	NS
Total use of Class I/III antiarrhythmic agents	1 (3.8%)	17 (25.0%)	0.020
Cardioversion	2 (8.0%)	6 (9.0%)	NS
Heparin	7 (26.9%)	50 (73.5%)	<0.001
Discharge on warfarin	3 (11.5%)	25 (36.8%)	0.017

AF = atrial fibrillation; BB = β -adrenergic blocking agents; CCB = calcium channel blockers; POD = postoperative day.

Figure 1. A comparison of postoperative LOS for patients with normal sinus rhythm (NSR), short-lived AF and recurrent/prolonged AF.

and demonstrate that such differences in AF patterns impact the LOS after CABG. Not surprisingly, we found a heterogeneous pattern of AF, consistent with the hypothesis that postoperative AF is not a uniform clinical condition. This information is important to physicians caring for cardiac surgery patients, as it helps to identify who might require early and aggressive therapy for postoperative AF.

In the current study, AF was common after cardiac surgery, occurring in about one third of all patients. The vast majority of patients developed AF by the third postoperative day. Multivariate analysis demonstrated that postoperative AF was significantly more frequent in older patients, or patients with a prior history of AF. These findings are consistent with reports from previous database analyses.^{1-3,5,9}

There was a large variance in the duration of the initial AF episode, with one fourth of patients experiencing AF for over 24 hours. Approximately

half of all patients with postoperative AF experienced subsequent AF episodes, while three fourths of all patients with AF had either prolonged or recurrent AF (recurrent/prolonged AF). Patients with recurrent/prolonged AF were as likely to be treated routinely with β -adrenergic blocking agents in the early postoperative period as patients without AF, or patients with short-lived AF. Recurrent/prolonged AF was not associated with a higher complication rate, but was associated with more frequent use of IV anticoagulation, antiarrhythmic therapy, and discharge on warfarin therapy.

LOS was significantly higher for patients with AF when compared with patients in NSR. However, when grouped according to the pattern of AF, LOS was only prolonged for patients with recurrent/prolonged AF. Multivariate analysis demonstrated that recurrent/prolonged AF was an independent predictor of prolonged LOS, and contributed an additional 1.1 days to hospital LOS after accounting for other confounding variables. In a recent study, examining risk factors and outcome of AF after cardiac surgery,¹⁰ the authors reported a 42% incidence of recurrent AF among patients with postoperative AF. They too demonstrated that patients with recurrent AF had a longer LOS compared with patients with a single episode of AF. However, the longer LOS for patients with recurrent AF appeared to be related to a higher rate of postoperative complications. In our study, patients with recurrent/prolonged AF had similar complication rates, but were more likely to be treated with anticoagulation, and antiarrhythmic therapy. We attribute the increased LOS for patients with recurrent/prolonged AF to be a result of the additional days used to observe these patients and/or to initiate and titrate therapy.

In view of this information, it may be worthwhile to consider a strategy that focuses on rate control and the initiation of early anticoagulation once recurrent/prolonged AF is recognized. This would incorporate the routine use of β -adrenergic blocking agents for all postoperative patients (unless there is a contraindication), and possibly the institution of low molecular weight heparin as a bridge to warfarin therapy once recurrent/prolonged AF is recognized.¹¹ Whether restoration of sinus rhythm should be attempted is still a matter of debate. Recent data¹² suggest little difference between a primary rate control strategy and a strategy that restores sinus rhythm (antiarrhythmic therapy with or without electrical cardioversion). Since most AF

Table 4. Independent Predictors of Prolonged Length of Stay

Variable	Regression Coefficient	Standard of Error	P-Value
Complications	3.56	0.68	<0.001
Recurrent/prolonged AF	1.14	0.30	<0.001
Digoxin	3.20	0.89	<0.001
Age (for every 10 years)	0.74	0.25	0.003

AF = atrial fibrillation.

resolves by 8 weeks after surgery,¹² anticoagulation can subsequently be discontinued during follow-up. For the small number of patients who remain in AF beyond 8 weeks, cardioversion may then be offered. Further investigation is needed to determine whether this approach improves LOS, while maintaining optimal patient care.

Study Limitations

This report is based on a retrospective, though detailed, data collection and review, which focused on the occurrence and characteristics of postoperative AF. It is possible that short, asymptomatic arrhythmic episodes were missed after discontinuation of telemetry, hence potentially overestimating the number of patients with "short-lived and nonrecurrent AF." The only true way to identify all AF episodes would be to perform a prospective registry with continuous telemetry until discharge from the hospital. There was no uniform protocol for AF management: rate and rhythm control, as well as the use of anticoagulation were given at the discretion of the attending physician, potentially biasing the results. However, most cardiologists and surgeons at our institution have similar practice patterns based on hospital and expert opinion recommendations. Finally, long-term follow-up of postdischarge AF outcome was not performed.

CONCLUSIONS

AF is common after cardiac surgery, and has a heterogeneous pattern. A substantial minority of AF is short-lived and isolated with no impact on LOS; however, recurrent or prolonged AF significantly prolongs LOS. Efforts should focus on aggressively treating patients who develop the

features of postoperative recurrent/prolonged AF in an attempt to improve LOS and decrease resource utilization.

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