Does preoperative atrial fibrillation influence early and late outcomes of coronary artery bypass grafting?

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Objective: The study objective was to describe the independent effect of preoperative atrial fibrillation on the outcome of coronary artery bypass grafting, including the causes of death (cardiac vs noncardiac).

Methods: We analyzed the outcome of patients with preoperative atrial fibrillation who underwent on-pump coronary artery bypass grafting between 1993 and 2002 and compared them with matched controls in sinus rhythm; matching variables were age, gender, ejection fraction, and numbers of diseased coronary arteries and distal anastomoses. Direct patient follow-up focused on late complications and reinterventions, and we investigated causes for all deaths.

Results: Operative mortality (1.6% vs 1.9%, $P = .79$) was similar in patients with preoperative atrial fibrillation ($n = 257$) compared with patients in sinus rhythm ($n = 269$). The patients with atrial fibrillation had longer hospital stays (9 ± 6 days vs 8 ± 6 days, $P = .0008$) and a trend to more frequent early readmissions (13% vs 9%, $P = .08$). During follow-up (median 6.7 years, maximum 12 years), late hospital admission was more frequent in patients with atrial fibrillation (59% vs 31%, $P < .0001$). Risk of late mortality (all causes) in patients with atrial fibrillation was increased by 40% compared with patients in sinus rhythm ($P = 0.02$), and the late cardiac death rate in the atrial fibrillation group was 2.8 times that of the sinus rhythm group ($P = .0004$). Major adverse cardiac events occurred in 70% of patients with preoperative atrial fibrillation compared with 52% of patients in preoperative sinus rhythm ($P < .0001$). Subsequent rhythm-related intervention, including pacemaker implantations, was more common in the atrial fibrillation group (relative risk = 2.1, $P = .0027$).

Conclusions: Uncorrected preoperative atrial fibrillation in patients undergoing coronary artery bypass grafting is associated with increased late cardiac morbidity and mortality and poor long-term survival. These data support consideration of atrial fibrillation surgery at the time of coronary artery bypass grafting.

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Atrial fibrillation (AF) is a common tachyarrhythmia, affecting approximately 2.2 million people in the United States, and the median age of patients with AF is 70 years.¹ As a result of the increasing age of patients requiring myocardial revascularization and the predisposing influence of ischemic heart disease, AF is not infrequent in patients undergoing coronary artery bypass grafting (CABG). Several population-based studies and nonsurgical reports²⁻⁴ have identified AF as a marker of increased cardiovascular morbidity and mortality because of its association with other cardiovascular diseases. There are few studies examining the impact of concurrent AF on the long-term outcome in patients after surgical correction of the associated cardiovascular disease.

Quader and associates⁵ reported a reduction in long-term survival in patients undergoing CABG with preoperative AF and recommended concomitant surgical

Abbreviations and Acronyms

AF	= atrial fibrillation
CABG	= coronary artery bypass grafting
CI	= confidence interval
SR	= sinus rhythm
RR	= relative risk

ablation. Apart from this study, which focused only on overall survival, there are no studies that comprehensively evaluate the long-term adverse effects of uncorrected preoperative AF after CABG in patients receiving optimal medical treatment. Moreover, the impact of the clinical type and duration of AF on outcome in this patient population is not known. Because of current enthusiasm for surgical ablation of AF, it is important to investigate the influence of AF on outcome to identify which patients might benefit from concomitant ablation procedures.

The objectives of this study were to determine the prevalence of AF in patients undergoing CABG and to compare the early and late clinical outcome between patients with preoperative AF and patients in normal sinus rhythm (SR), with specific reference to adverse cardiac and cerebrovascular events and long-term survival; further, the study addressed the influence of type and duration of AF on clinical outcome.

Patients and Methods**Study Population and Matching**

The cardiovascular surgery database of our institution contains information on 7498 patients who underwent isolated CABG between January 1993 and December 2002, of whom 650 (8.7%) had preoperative AF. The institutional review board approved the use of patients' data for this study. Patients were excluded if they had a history of cardiac arrhythmia other than AF, permanent sequelae of stroke, prior implantation of a permanent pacemaker or cardioverter defibrillator, prior AF ablation, surgery within 7 days of acute myocardial infarction, and off-pump CABG. Patients with cancer who had a limited life expectancy were also excluded. Of 4151 patients who met the study criteria and for whom complete matching variables were available, 284 had preoperative AF confirmed by electrocardiograms, and 3867 were in SR.

Previous publications suggested a 10% reduction in late survival of patients with AF undergoing CABG compared with controls; with these data, we estimated that 200 patients would be needed in each group to demonstrate this difference (90% power). We then used the Greedy method⁶ to identify the best matched control (preoperative SR) for each case based on age, gender, ejection fraction, extent of coronary artery disease, and the number of distal anastomoses. Demographic characteristics, clinical details, and perioperative variables from our database were supplemented by review of patient charts, operative notes, and electrocardiographic, angiographic, and echocardiographic reports (Table 1).

Definitions

Terminologies used in the description of the types of AF in the literature can be confusing. The international consensus on nomenclature and classification recently released a position paper on the clinical classification of AF,⁷ which classifies AF into initial event, paroxysmal, persistent, and permanent types. During the study period this classification was not in use, and data relating to AF were recorded using the simpler classification proposed by Cox,⁸ which divides AF on the basis of clinical presentation into intermittent and continuous types. However, both classifications share common arrhythmia patterns; paroxysmal and persistent AF are characterized by recurrent arrhythmia (eg, intermittent AF), and permanent AF (eg, continuous AF) has established arrhythmia. We therefore categorized preoperative AF on the basis of clinical presentation into paroxysmal/persistent and permanent types, and into short and long duration to enable comparison of clinical outcomes.

- *Paroxysmal/persistent AF* describes recurrent AF.
- *Permanent AF* denotes established AF that is present at all times.
- *Short-duration AF* refers to preoperative AF of 3 months' duration or less.
- *Long-duration AF* refers to preoperative AF of more than 3 months' duration.

Follow-up

Both the Social Security Death Index and Mayo Clinic's patient registration were queried for deaths, and certificates were obtained for all deaths. A survey questionnaire was then sent to all surviving patients in the study to gather information including symptom change, occurrence of adverse cardiac and cerebrovascular events, cardiac-related hospital readmission after the index CABG operation, further cardiac interventions, medications, and cardiac rhythm (Table 2).

Follow-up data were available for 257 patients with preoperative AF and 269 matched patients in SR. These 526 patients constitute the study population.

Statistical Analysis

The primary end points were (1) mortality, both overall mortality and cardiac-related deaths, and (2) major adverse cardiac and cerebrovascular events, which include cardiac death, myocardial infarction, heart failure, further cardiac intervention, and stroke. Secondary end points of this study were length of hospital stay, cardiac-related hospital readmissions, Coumadin and antiarrhythmic drug use, and bleeding/thromboembolic complications.

Categorical variables are expressed as percentages, and continuous variables are expressed as the mean $\pm$ standard deviation, unless otherwise stated. Univariate analysis was performed using the chi-square test for qualitative data, the Wilcoxon rank test for quantitative data, and the Kaplan-Meier method for long-term outcomes. Multivariable analysis was done using Cox proportional hazards models and logistic regression. The stepwise model selection procedure was used to identify risk factors associated with each end point of interest. If the primary variable of interest (AF vs SR) was selected by the stepwise procedure, then this is the model reported in the results section. Otherwise, if the AF/SR grouping variable was not chosen, then it was forced into the final

TABLE 1. Baseline characteristics and in-hospital outcome of patients undergoing coronary artery bypass grafting with and without preoperative atrial fibrillation

Variable	SR group (n = 269) No. (%)	AF group (n = 257) No. (%)	P value
Demographics			
Mean age (y)*	70 ± 8	71 ± 8	.26
Female gender*	57 (21)	54 (21)	.96
Mean BMI (kg/m ²)	28 ± 5	29 ± 5	.59
Clinical symptoms			
Angina class			.16
I	17 (6)	24 (9)	
II	27 (10)	14 (5)	
III	128 (48)	122 (47)	
IV	97 (36)	97 (38)	
NYHA class			.22
I	11 (4)	7 (3)	
II	25 (9)	13 (5)	
III	132 (49)	136 (53)	
IV	101 (38)	101 (39)	
Unstable angina	42 (16)	31 (12)	.24
History			
Stroke	27 (10)	27 (11)	.86
Carotid endarterectomy	10 (4)	6 (2)	.36
Angioplasty/stent	70 (26)	85 (33)	.08
Comorbidities			
Diabetes mellitus	69 (26)	89 (35)	.02
Renal insufficiency	13 (5)	14 (5)	.75
Hypertension	192 (71)	190 (74)	.51
COPD	25 (9)	36 (14)	.09
Cardiac morbidity			
Mean ejection fraction*	0.56 ± 0.16	0.53 ± 0.14	.14
Coronary artery disease*			.77
1-vessel	8 (3)	8 (3)	
2-vessel	42 (16)	46 (18)	
3-vessel	219 (81)	203 (79)	
Left main stem disease	74 (28)	80 (31)	.36
Myocardial infarction	139 (52)	141 (55)	.46
Cardiomegaly	84 (32)	111 (43)	.007
Operative details			
Surgery priority			.32
Elective	240 (89)	238 (93)	
Urgent	22 (8)	16 (6)	
Emergency	7 (3)	3 (1)	
Distal anastomosis*			.96
1	3 (1)	2 (1)	
2	38 (14)	30 (12)	
3	115 (43)	114 (44)	
4	93 (35)	93 (36)	
5	19 (7)	17 (7)	
6	1 (0)	1 (0)	
ITA use			.53
None	11 (4)	15 (6)	
Left	247 (92)	233 (91)	
Right	2 (1)	0	

TABLE 1. (Continued)

Variable	SR group (n = 269) No. (%)	AF group (n = 257) No. (%)	P value
Bilateral	9 (3)	9 (3)	
Mean crossclamp time (min)	50 ± 18	50 ± 18	.52
Perfusion time	92 ± 32	91 ± 33	.44
Postoperative data			
Inotropic support	117 (43)	129 (50)	.12
IABP use	17 (6)	11 (4)	.30
Reoperation for bleeding	13 (5)	8 (3)	.31
Sternal wound infection	2 (1)	1 (0)	1.00
Stroke	8 (3)	8 (3)	.93
Prolonged ventilation	20 (7)	26 (10)	.28
Renal failure	15 (6)	17 (7)	.62
Operative death	5 (2)	4 (2)	1.00
Hospital length of stay	8.0 ± 5.6	9.3 ± 6.3	.0008
30-d readmission	23 (9)	34 (13)	.08

SR, Sinus rhythm; AF, atrial fibrillation; BMI, body mass index; NYHA, New York Heart Association; COPD, chronic obstructive pulmonary disease; ITA, internal thoracic artery; IABP, intra-aortic balloon pump. *Matching variables.

model provided by the stepwise procedure. The SAS statistical analysis system (SAS Institute Inc, Cary, NC) was used for data analysis.

Results

In-hospital Outcome

Table 1 compares patient demographics and baseline variables. The 2 groups were similar aside from cardiomegaly and diabetes, which were more prevalent in the AF group.

The AF and SR groups did not differ in operative characteristics or rates of perioperative complications. The operative (30-day) mortality in the AF group was 1.6% versus 1.9% for the SR group ($P = .79$). Patients with preoperative AF had a longer average length of postoperative hospital stay compared with patients in SR (9 ± 6 days vs 8 ± 6 days, $P = .0008$).

Late Outcome

The median follow-up for the entire study population was 6.7 years (maximum 12 years). Both the AF and SR groups had an equivalent duration of follow-up (6.7 vs 6.6 years). Symptom improvement, as measured by change in the angina class ($P = .51$), and New York Heart Association functional class ($P = .74$) were comparable between the 2 groups. Patients with preoperative AF had a tendency toward more readmissions within 30 days postoperatively for problems including congestive heart failure, AF, recurrent angina, and cardiac procedures (13% vs 9%, $P = .08$). Beyond 30 days, the hospital readmission rate was significantly increased in patients with preoperative AF (54% vs

TABLE 2. Late results in the two groups of patients

	SR group		AF group		P value
	Total No.	Frequency (%) or mean $\pm$ SD	Total no.	Frequency (%) or mean $\pm$ SD	
Late all-cause mortality	264	86 (33)	253	104 (41)	.02
Clinical symptoms	119		95		
Angina class					.55
I		108 (91)		84 (88)	
II		9 (8)		8 (8)	
III		1 (1)		3 (3)	
IV		1 (1)		0	.44
Angina class change					
Increase		0		2 (2)	
No change		10 (8)		8 (8)	
Decrease		109 (92)		85 (89)	
Medications					
Coumadin	140	17 (12)	121	68 (56)	<.0001
Beta-blocker	140	92 (66)	114	74 (65)	.89
ACE inhibitor	139	64 (46)	115	57 (50)	.58
Antiarrhythmics	138	20 (14)	112	55 (49)	<.0001
Hospital admissions	143	45 (32)	133	78 (59)	<.0001
Cardiac rhythm	141		122		<.0001
SR		115 (82)		34 (28)	
AF		24 (17)		81 (66)	
Paced rhythm		2 (1)		7 (6)	
Adverse events					
Cardiac events					
Cardiac death	264	16 (6)	253	38 (15)	.0004
Myocardial infarction	140	13 (9)	110	11 (10)	.85
Heart failure	140	8 (6)	121	26 (21)	.0002
Reintervention	140	25 (18)	124	41 (33)	.003
Stroke	142	14 (10)	119	17 (14)	.27
Bleeding/thromboembolism	140	17 (12)	114	24 (21)	.05

SD, Standard deviation; ACE, angiotensin-converting enzyme; SR, sinus rhythm; AF, atrial fibrillation.

32%, $P < .0001$). Overall (all-causes) mortality (relative risk [RR] = 1.4, $P = .02$) and late cardiac death (RR = 2.8, $P = .0004$) were more likely in the AF group compared with the SR group. In general, more major and minor adverse cardiac events were observed in the AF group (70% vs 52%, $P < .0001$). Late congestive heart failure (21% vs 6%, $P = .0002$), cardiac rhythm-related intervention (35% vs 18%, $P = .0027$), and bleeding/thromboembolism (21% vs 12%, $P = .05$) occurred more often in patients with preoperative AF. There was, however, no difference in late incidences of myocardial infarctions and strokes (Table 2). As expected, patients with preoperative AF had a higher use of Coumadin (56% vs 12%, $P < .0001$) and antiarrhythmics (49% vs 14%, $P < .0001$).

Patients with preoperative AF had comparatively poor late overall survival and freedom from late cardiac death (Figure 1, A, B). The 1-, 5-, and 10-year overall survivals were 96%, 74%, and 41%, respectively, for the AF group compared with 97%, 83%, and 58%, respectively, for the SR group ($P = .02$). The corre-

sponding 1-, 5-, and 10-year freedom from cardiac death values were 98%, 88%, and 74%, respectively, for the AF group compared with 100%, 97%, and 90%, respectively, for the SR group ($P = .0004$). Figure 2 displays the trend of subsequent cardiac rhythm-related intervention after the index CABG operation in both groups of patients. More patients with AF underwent subsequent cardiac rhythm-related intervention in the form of cardioversion or AF ablation, and in the long term, patients with preoperative AF had a 2-fold increase in the risk of subsequent cardiac rhythm-related intervention compared with patients in SR.

Preoperative Atrial Fibrillation As a Predictor of Adverse Outcomes After Coronary Artery Bypass Grafting

In the multivariable analysis, preoperative AF was an independent predictor of prolonged hospital stay ($P = .03$), major adverse cardiac events (hazard ratio 2.51, 95% confidence interval [CI]: 1.65-3.84, $P < .0001$), all-cause mortality (RR 1.34, 95% CI: 0.995-1.80, $P = .05$), and cardiac

Figure 1. Kaplan-Meier survival curves for patients after CABG. **A**, Overall survival. **B**, Freedom from cardiac death. **AF**, Atrial fibrillation; **SR**, sinus rhythm.

death (hazard ratio 2.75, 95% CI: 1.50-5.02, $P = .001$); this was true after controlling for other patient characteristics such as chronic obstructive pulmonary disease, diabetes, postoperative renal failure, cardiomegaly, congestive heart failure, preoperative stroke, and myocardial infarction. **Table 3** shows other independent predictors of adverse outcome after CABG.

Influence of Type and Duration of Atrial Fibrillation

The type of preoperative AF was known with certainty in 225 patients (88%). In this subset, late all-cause mortality was twice as likely to occur in patients with permanent preoperative AF compared with patients with paroxysmal/persistent AF (RR = 2, $P = .0007$), resulting in 5- and 10-year survivals of 67% and 22% vs 77% and 56%, respectively (**Figure 3**, A). However, the rates of cardiac death

Figure 2. Trends for subsequent cardiac rhythm-related intervention after CABG in patients with preoperative SR and AF. **AF**, Atrial fibrillation; **SR**, sinus rhythm.

and other adverse cardiac and cerebrovascular events were similar between patients with both types of AF. Among patients with known duration of AF (118 patients, 46%), there was no difference in the length of hospital stay,

TABLE 3. Predictors of adverse clinical outcome by multivariate analysis

	Odds ratio	95% CI	P value
Adverse cardiac event and stroke			
Preoperative AF	2.4	1.5-3.7	.0001
Diabetes	3.3	1.9-5.9	<.0001
History of stroke	3.8	1.4-10.2	.007
Cardiomegaly	2.0	1.3-3.3	.004
	Hazard ratio	95% CI	P value
Late cardiac death			
Preoperative AF	2.7	1.50-5.02	.001
History of stroke	2.8	1.40-5.39	.003
Chronic obstructive pulmonary disease	2.7	1.41-4.98	.002
Postoperative dialysis	17.6	2.16-143.82	.007
Myocardial infarction	1.9	1.07-3.48	.029
Cardiomegaly	1.8	1.05-3.12	.032
Late all-cause mortality			
Preoperative AF	1.3	0.99-1.8	.054
History of stroke	2.4	1.64-3.46	<.0001
Chronic obstructive pulmonary disease	2.0	1.36-2.84	.0003
Myocardial infarction	1.4	1.01-1.834	.043
Cardiomegaly	1.5	1.15-2.07	.003
Diabetes	1.6	1.16-2.13	.004
Postoperative dialysis	11.600	3.02-44.48	.0004

CI, Confidence interval; AF, atrial fibrillation.

Figure 3. Kaplan–Meier survival curves for patients with different subclasses of preoperative AF after CABG. A, Survival of patients with the 2 patterns of AF. B, Comparison of survival on the basis of AF duration. AF, Atrial fibrillation.

adverse cardiac and cerebrovascular events, and overall survival between patients with short-duration and long-duration AF (Figure 3, B).

Discussion

The overall long-term survival of patients with preoperative AF undergoing CABG has been reported to be inferior to that of patients without preoperative AF.⁵ Quader and associates⁵ reviewed 46,984 patients who underwent CABG between 1972 and 2000 and reported a preoperative AF prevalence rate of 0.96% (451 patients). They identified preoperative AF both as a marker of severe cardiovascular disease and as a determinant of poor long-term survival using propensity matching. Our patient population differs considerably as evidenced by the 8.7% prevalence of AF.

The present study also differs in that we conducted active follow-up and evaluated causes of late death and incidences of late morbid events, as well as the influence of types and duration of preoperative AF on clinical outcomes.

Long-term Survival and Adverse Cardiac and Cerebrovascular Events

Preoperative AF is associated with decreased long-term survival after CABG. New and notable findings from this study include increased rates of late adverse events, including death from cardiac causes such as heart failure and arrhythmia. Preoperative AF in patients undergoing CABG increased all-cause mortality by 40%, the likelihood of cardiac death by approximately 3 folds (RR = 2.8), and the risk of major adverse cardiac events by 2.5 times. The presence of preoperative AF doubled the risk of subsequent cardiac (rhythm-related) intervention, despite continuing optimal medical treatment of AF. The cohort of patients with AF in our study were receiving medical treatment with rate and/or rhythm control and anticoagulation, which may explain the relatively low rate of cerebrovascular accident in the AF group. Similarly, late myocardial infarction was rare in both groups. Notwithstanding, major cardiac adverse events (eg, heart failure and subsequent cardiac intervention) were more frequent in patients with preoperative AF. Impairment of both atrial and ventricular function occurs in AF,^{9,10} and this may contribute to the high rate of late postoperative congestive heart failure, which leads to clinical deterioration with poor prognosis.¹¹ Together with recurrent episodes of rapid AF and recurrent angina, heart failure accounted for 86% of late hospital readmissions.

Many patients with AF are symptomatic with palpitations and fatigue, so it is not surprising that patients with AF were often readmitted for rate control and/or further rhythm-related intervention such as pacemaker placement with or without ablation of the atrioventricular node. Similar findings have been reported in nonsurgical series.^{12,13} Anticoagulation-related complications, such as gastrointestinal bleeding and epistaxis, occurred more often in patients with preoperative AF because of their high use of Coumadin. Both subtherapeutic and supratherapeutic levels of anticoagulation resulted in hospital readmission in some patients with AF in our study.

Beta-blockers and angiotensin-converting enzyme inhibitors confer a prognostic benefit in subsets of patients with coronary artery disease^{14,15} and after CABG.¹⁶ In this study, postoperative medical treatment was similar in patients with and without preoperative AF and thus does not explain the differences in late survival. Also, the use of antiarrhythmics for rate or rhythm control did not confer any survival advantage among patients with AF.

Among patients with preoperative AF, those with permanent AF were twice as likely to have late mortality. Gajewski and Singer¹⁷ first reported a differential survival

impact of the clinical type of AF in a study of insurance applicants. Electrical and anatomic remodeling of the atria occurs in AF^{18,19} and leads to progression from recurrent to established arrhythmia ("AF begets AF"). It is important to note, however, that the duration of preoperative AF did not influence clinical outcomes after CABG. It is possible that the arbitrary 3-month cutoff used in this study and based on our previous report in patients with mitral valve disease²⁰ may not be long enough in coronary artery disease for the development of sufficient morphologic changes to influence outcome.

The preoperative cardiac rhythm of patients did not affect late symptom improvement, probably because of the effect of CABG in relieving ischemia. Further, adequate medical treatment of AF can improve symptoms without affecting the long-term morbidity and mortality.²¹

Preexisting AF exerts a profound impact on prognosis after CABG, but it remains to be determined whether AF ablation at the time of CABG would alter long-term results. Preoperative AF is a risk factor for adverse cardiac events but a weak predictor of all-cause mortality; frequently coexists with cardiomegaly, which has similar effects on clinical outcome (Table 3). Thus, it is possible that the correction of AF could achieve greater clinical benefit in patients without cardiomegaly. However, even in patients with cardiomegaly and history of stroke, the likelihood of poor outcome may also be reduced by AF ablation. These data also support consideration of AF surgery in patients with permanent AF.

Strengths and Limitations

This study was designed to compare the clinical outcomes of matched groups of patients who had preoperative AF with those in preoperative SR and was adequately powered to detect important differences in the primary and secondary dependent variables. The comprehensive investigation of the extent of the impact of preoperative AF on the late clinical outcome in patients managed with optimal medical treatment is relevant to contemporary practice and therefore a valuable addition to the cardiovascular medicine literature.

Although the groups were matched for important prognostic variables, more patients with preoperative AF had diabetes and cardiomegaly, which can affect outcome. To control the influence of these variables, we used the stepwise model selection procedure in the multivariate analysis. In the subset analysis of the impact of AF types, we combined paroxysmal and persistent AF on the basis of a similar arrhythmia pattern, because the distinction between the 2 can be subtle and difficult to reliably establish in a retrospective study. This categorization is consistent with current medical and surgical therapeutic strategies of managing AF. Another potential weakness of this study is recall bias due to

reliance on self-reporting for follow-up data acquisition. The influence of this limitation is reduced by the supplemental follow-up data collection from hospital records for patients who attended the Mayo Clinic integrated health care system. Moreover, the follow-up information obtained related to major events that patients are more likely to recall. Follow-up heart rhythm was confirmed by electrocardiography in only 15% of patients who were under surveillance locally; otherwise, the patients' responses to the questionnaire were accepted. It is noteworthy that in the patients with follow-up electrocardiograms, there was 100% concordance with the questionnaire response for the late cardiac rhythm.

Conclusions

Preoperative AF in patients undergoing on-pump CABG predisposes them to high rates of early and late cardiac morbidity. Hospital stay after surgery is prolonged, and late hospital readmissions for cardiac-related events are common. Patients with preexisting AF have adverse cardiac events more frequently than those in normal SR after CABG despite optimal postoperative medical treatment with rate and/or rhythm control and anticoagulation. Long-term survival in patients with preoperative AF is steadily reduced by higher rates of cardiac and all-cause mortality. Patients with permanent AF have worse long-term survival compared with patients with paroxysmal/persistent AF. Whether ablation of AF at the time of CABG would improve the prognosis is yet to be determined, but these data support consideration of concomitant AF surgery.

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Notice of Correction

Shigemura N, Akashi A, Funaki S, Nakagiri T, Inoue M, Sawabata N, et al. Long-term outcomes after a variety of video-assisted thoracoscopic lobectomy approaches for clinical stage IA lung cancer: A multi-institutional study. *J Thorac Cardiovasc Surg.* 2006;132:507-12.

The authors report the following error in data analysis: [Figure 3](#) shows the postoperative physical activity of the patients using an accelerometer to quantify their recovery from surgery. The data pertaining to all patients in one of the participant hospitals who received the a-VATS approach are inaccurate. All a-VATS results have been removed from the revised [Figure 3](#). As a result, the authors can no longer conclude that a significant difference exists in the recovery times between the a-VATS and c-VATS groups. The significant difference in the recovery times between the c-VATS and open thoracotomy groups remains valid. All other results from the study remain accurate.

Revised Figure 3. Comparison of the postoperative physical ability as determined by Active Tracer and expressed as the percentage of the preoperative 24-hour value. Time points included are before surgery and 0, 1, 2, 3, 4, 5, and 6 days postoperatively. Each value represents the mean $\pm$ standard error at each time point. * $P < .05$ for complete VATS (c-VATS) versus open thoracotomy on postoperative days 2 to 5.