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ORIGINAL RESEARCH

Natural Course of New-Onset Postoperative Atrial Fibrillation after Noncardiac Surgery

Junho Hyun, MD*; Min Soo Cho, MD*; Gi-Byoung Nam, MD; Minsoo Kim, MD; Ungjeong Do, MD; Jun Kim, MD; Kee-Joon Choi, MD; You-Ho Kim, MD

BACKGROUND: Postoperative atrial fibrillation (POAF) is common after cardiac surgery, but little is known about its incidence and natural course after noncardiac surgery. We evaluated the natural course and clinical impact of POAF and the long-term impact of anticoagulation therapy in patients without a history of atrial fibrillation (AF) undergoing noncardiac surgery.

METHODS AND RESULTS: We retrospectively analyzed the database of Asan Medical Center (Seoul, Korea) to identify patients who developed new-onset POAF after undergoing noncardiac surgery between January 2006 and January 2016. The main outcomes were AF recurrence, thromboembolic event, and major bleeding during follow-up. Of 322 688 patients who underwent noncardiac surgery, 315 patients (mean age, 66.4 years; 64.4% male) had new-onset POAF with regular rhythm monitoring after discharge. AF recurred in 53 (16.8%) during 2 years of follow-up. Hypertension (hazard ratio, 2.12; P=0.02), moderate-to-severe left atrial enlargement (hazard ratio, 2.33; P=0.007) were independently associated with recurrence. Patients with recurrent AF had higher risks of thromboembolic events (11.2% versus 0.8%; P<0.001) and major bleeding (26.9% versus 4.1%; P<0.001) than those without recurrence. Patients with recurrent AF and without anticoagulation were especially predisposed to thromboembolic events (P<0.001). Overall, anticoagulation therapy was not significantly associated with thromboembolic events (1.4% versus 2.5%, P=0.95).

CONCLUSIONS: AF recurred in 16.8% of patients with POAF after noncardiac surgery. AF recurrence was associated with higher risks of adverse clinical outcomes. Considering the high risk of anticoagulation-related bleeding, the benefits of routine anticoagulation should be carefully weighed in this population. Active surveillance for AF recurrence is warranted.

Key Words: anticoagulation ■ postoperative atrial fibrillation ■ recurrence

Atrial fibrillation (AF) is the most common form of arrhythmia in clinical practice. Patients are especially vulnerable to AF during the immediate postoperative period because of surgery-related transient factors such as inflammation, oxidative stress, and sympathetic activation.[1] Postoperative atrial fibrillation (POAF) after cardiac surgery is generally regarded as a transient phenomenon and is associated with higher medical cost, longer hospital stay, and higher risk of disability.[2,3] Recent studies suggested that patients with POAF have a higher risk of ischemic stroke not only after cardiac surgery but also after noncardiac surgery[4–6]; however, the natural course of POAF after noncardiac surgery and its long-term impact on the risk of ischemic stroke are not well-elucidated.[7,8] Moreover, little is known about the effects of standard anticoagulation after discharge in patients with POAF and reported evidence of anticoagulation therapy is based largely on claim data. Therefore, we evaluated the natural course and the clinical impact of POAF in patients who underwent noncardiac surgery on the basis of clinical data. In addition, we investigated the long-term clinical impact of standard anticoagulation therapy on the subsequent risk of thromboembolic events in such patients.

Correspondence to: Gi-Byoung Nam, MD, Asan Medical Center, University of Ulsan College of Medicine, 88, Olympic-ro 43-gil, Songpa-gu, Seoul 05505, South Korea. E-mail: gbnam@amc.seoul.kr

*Dr. Hyun and Dr. Cho contributed equally to this work.

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CLINICAL PERSPECTIVE

What Is New?

- A substantial proportion of new-onset postoperative atrial fibrillation after noncardiac surgery recurred in the long-term, and the recurrence of postoperative atrial fibrillation was associated with adverse clinical outcomes such as thromboembolic events and major bleeding.
- Anticoagulation therapy was not significantly associated with adverse clinical events in the overall population and those with recurrent postoperative atrial fibrillation.

What Are the Clinical Implications?

- Considering the high risk of anticoagulation-related bleeding, the benefits of routine anticoagulation should be carefully weighed in patients with recurrent postoperative atrial fibrillation after noncardiac surgery.
- Active surveillance for monitoring the recurrence of atrial fibrillation is warranted.

Nonstandard Abbreviations and Acronyms

POAF	postoperative atrial fibrillation

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request. This study has been approved by the Institutional Review Board of Asan Medical Center. The study was considered minimal risk to study participants, and informed consent was waived.

Study Population

We gathered data on patients who were >18 years old and underwent any noncardiac surgeries with either local or general anesthesia at Asan Medical Center (Seoul, Korea) between January 2006 and January 2016. Among them, we identified those who had AF rhythm during the index hospitalization, and excluded the following patients from the analysis: (1) patients who developed AF before the index surgical procedure; (2) patients in whom the first episode of POAF developed after discharge or >90 days of the postoperative period during the index admission; (3) patients with a first documented POAF that persisted until discharge; (4) patients with no clinical data in the follow-up period after discharge; (5) patients with an in-hospital thromboembolic event during index admission; and (6) patients with valvular AF, defined as moderate or severe rheumatic mitral stenosis or mechanical prosthetic valve. After collecting the study population according to inclusion and exclusion criteria, we further excluded patients with new-onset POAF, but without at least 1 regular electrocardiographic surveillance during the follow-up period. Data on the study subjects were extracted from the Asan Biomedical Research Environment System, in which all medical records, images, and the results of evaluations were available in an anonymized form. For the diagnosis of POAF, all electronic medical records were reviewed by 2 of the authors (J.H. and M.S.C.).

Baseline data were collected from before or during the index hospitalization for noncardiac surgery. ECG was obtained by standard 12-lead acquisition, and the diagnosis of AF was adjudicated using ECGs showing irregular RR intervals and no discrete P waves.[9] All electrocardiographic data were independently adjudicated by 2 of the authors (J.H. and M.S.C.), and a third cardiologist (G.B.N.) adjudicated in case of discordance. Intra- and interobserver agreements showed kappa values of 0.93 and 0.91, respectively. The specific method for rhythm monitoring during hospitalization and after discharge is described in detail in Table S1. Echocardiographic data were obtained and classified according to the current recommendation from the American Society of Echocardiography and the European Association of Cardiovascular Imaging.[10] Left atrial enlargement, left ventricular ejection fraction, and left ventricular end-diastolic diameter were also investigated and graded according to the recommendation. Moderate to severe left atrial enlargement was defined as a diameter ≥43 mm in women and ≥47 mm in men.

Definition of Variables and Study Outcomes

The main outcome was ischemic stroke or systemic embolism after the occurrence of POAF. Stroke was defined as a permanent neurologic deficit with imaging evidence of cerebral artery occlusion, and the diagnosis of ischemic stroke was adjudicated by independent neurologists who were blinded to the patient characteristics. The outcome of systemic embolism was defined as an acute loss of peripheral perfusion by the occlusion of the artery that did not supply the brain or the heart. The secondary outcomes were all-cause mortality, recurrence of AF, and bleeding events. All outcome events were assessed and adjudicated independently by 2 of the authors (J.H. and M.S.C.). AF was defined as recurrent when it was documented on any forms of ECG such as 12-lead ECG, Holter monitoring, or in-hospital telemonitoring data after discharge. Bleeding events were defined and classified

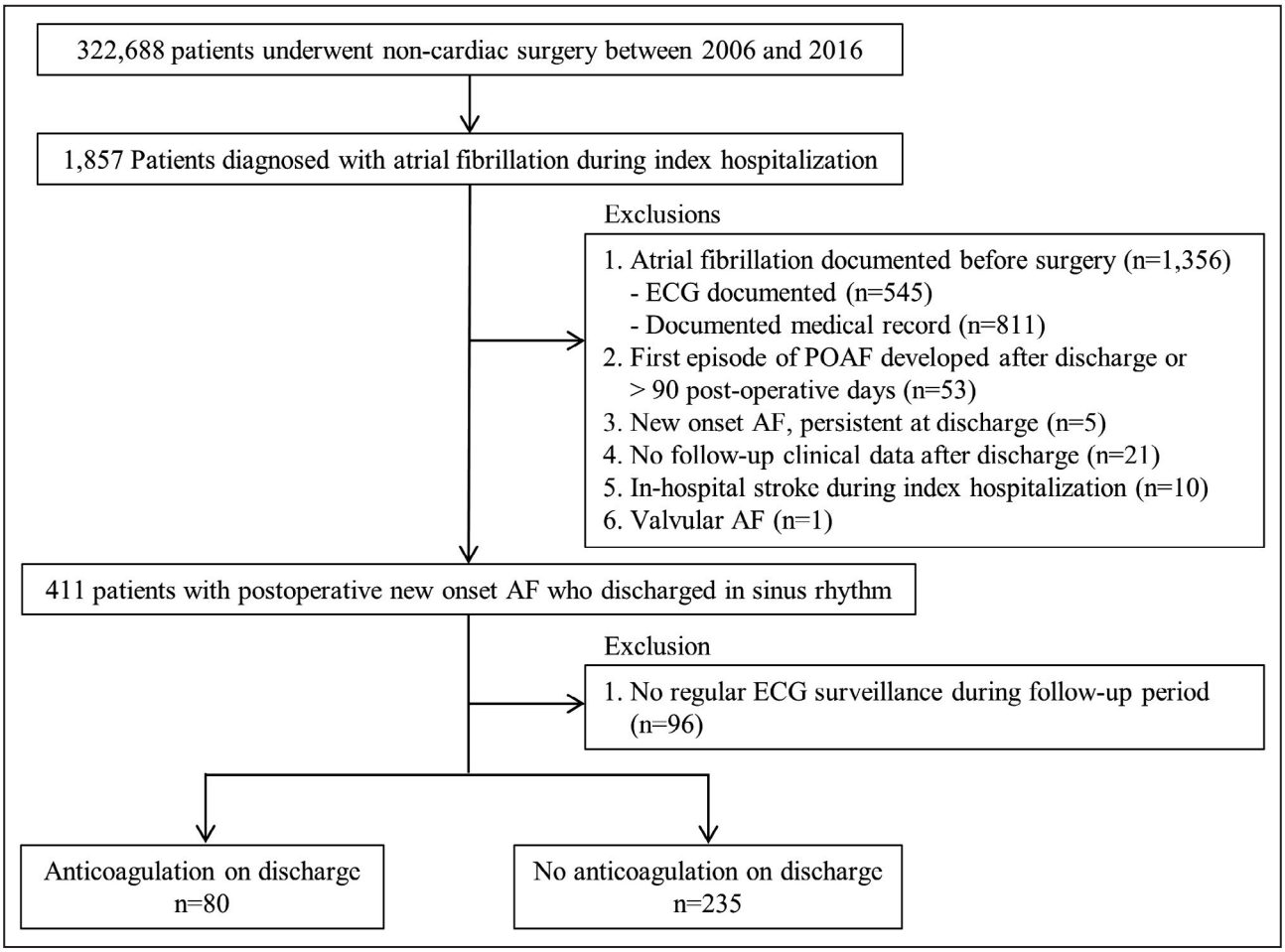

Figure 1. Patient selection flow.

by the Bleeding Academic Research Consortium definition for bleeding[11], and major bleeding was defined as Bleeding Academic Research Consortium type 3 bleeding. High-risk surgery was defined according to the Revised Cardiac Risk Index.[12] Vascular disease was defined as history of myocardial infarction, peripheral vascular disease, or aortic plaque.

Statistical Analysis

Continuous variables were analyzed using Student's *t*-test and presented as mean±SD; categorical variables were analyzed using the chi-squared test or Fisher's exact test as appropriate and presented as numbers with percentages. The cumulative incidences of ischemic stroke or systemic embolism, bleeding events, and mortality were estimated by the Kaplan-Meier method, and the differences were compared using the log-rank test. Clinical outcomes in patients who were on anticoagulation therapy at discharge but discontinued afterward were censored in the analysis. Multivariable Cox proportional hazard analyses were performed to calculate the hazard ratios of AF recurrence, major bleeding event, thromboembolic event, and all-cause death, with adjustment for variables that had clinical relevance or statistical significance (defined as $P<0.10$ on univariable Cox regression analyses). The proportional hazards assumption was tested by examining the log

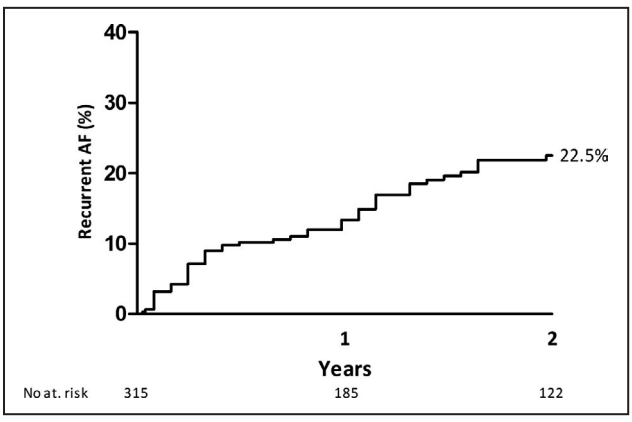

Figure 2. Kaplan–Meier curve of recurrent AF.
AF indicates atrial fibrillation.

Table 1. Baseline Characteristics of the Patients According to the Recurrence of AF and Anticoagulation Therapy

Variables	Overall (n=315)	AF Recurred (n=53)	No AF Recurred (n=262)	*P* Value	Anticoagulation (n=80)	No Anticoagulation (n=235)	*P* Value
Age, y	66.4±10.1	68.2±9.4	66.0±10.2	0.15	68.0±9.9	65.9±10.2	0.11
Male, n (%)	203 (64.4)	33 (62.3)	170 (64.9)	0.72	45 (56.3)	158 (67.2)	0.08
Body mass index, kg/m^2	23.4±4.3	23.7±2.8	23.4±4.6	0.52	23.9±3.5	23.2±4.5	0.25
Hypertension, n (%)	163 (51.7)	37 (69.8)	126 (48.1)	0.004	50 (62.5)	113 (48.1)	0.03
Diabetes mellitus, n (%)	82 (26.0)	16 (30.2)	66 (25.2)	0.45	26 (32.5)	56 (23.8)	0.13
Vascular disease, n (%)	39 (12.4)	12 (22.6)	27 (10.3)	0.01	10 (12.5)	29 (12.3)	0.97
Congestive heart failure, n (%)	6 (1.9)	3 (5.7)	3 (1.1)	0.06	3 (3.8)	3 (1.3)	0.17
CHA_2DS_2-VASc score	2.3±1.7	2.2±1.6	2.9±1.7	0.007	3.0±1.8	2.1±1.5	<0.001
CHA_2DS_2-VASc score≥2, n (%)	202 (64.1)	40 (75.5)	162 (61.8)	0.06	60 (75.0)	142 (60.4)	0.02
Antiplatelet therapy, n (%)	52 (16.5)	16 (30.2)	36 (13.7)	0.003	10 (12.5)	42 (17.9)	0.26
Anticoagulation therapy, n (%)	80 (25.4)	23 (43.4)	57 (21.8)	0.001			
High-risk surgery, n (%)	224 (71.1)	34 (64.2)	190 (72.5)	0.22	55 (68.8)	169 (71.9)	0.59
Type of surgery, n (%)				0.08			0.18
Intraperitoneal	137 (43.5)	21 (39.6)	116 (44.3)		33 (41.3)	104 (44.3)	
Intrathoracic	69 (21.9)	6 (11.3)	63 (24.0)		15 (18.8)	54 (23.0)	
Suprainguinal vascular	18 (5.7)	7 (13.2)	11 (4.2)		7 (8.8)	11 (4.7)	
Orthopedic	53 (16.8)	13 (24.5)	40 (15.3)		20 (25.0)	33 (14.0)	
Neurosurgery	22 (7.0)	3 (5.7)	19 (7.3)		3 (3.8)	19 (8.1)	
Head and neck	11 (3.5)	2 (3.8)	9 (3.4)		1 (1.3)	10 (4.3)	
Obstetric and gynecologic	4 (1.3)	1 (1.9)	3 (1.1)		1 (1.3)	3 (1.3)	
Other	1 (0.3)	0 (0.0)	1 (0.4)		0 (0.0)	1 (0.4)	
Echocardiographic parameters*							
Left atrial diameter, mm	39.0±6.2	40.5±7.3	38.6±5.9	0.09	39.6±6.6	38.7±6.0	0.27
Moderate to severe LAE, n (%)	44 (14.0)	14 (26.4)	30 (11.5)	0.004	17 (21.3)	27 (11.5)	0.03
LV ejection fraction, %	61.0±7.1	58.2±9.5	61.7±6.4	0.01	59.0±8.3	61.8±6.5	0.003
LV end-diastolic diameter, mm	48.2±5.4	48.0±5.8	48.2±5.3	0.84	48.2±6.0	48.2±5.1	0.94
LV septal wall thickness, mm	9.7±1.9	10.1±2.2	9.7±1.9	0.11	9.6±1.5	9.8±2.1	0.42
Mitral E/e′ ratio	12.8±6.6	14.4±11.3	12.5±5.1	0.26	14.4±9.8	12.2±4.7	0.08
Peak TR velocity, m/sec	2.5±0.4	2.6±0.4	2.5±0.4	0.007	2.6±0.5	2.5±0.4	0.009

Values are mean±SD or n (%). AF indicates atrial fibrillation; LAE, left atrial enlargement; LV, left ventricular; and TR, tricuspid regurgitation.
*Echocardiographic data were available in 293 (93.0%) patients.

(–log survival) curves and partial (Schoenfeld) residuals. We established a three-step Cox proportional hazards model. All comparisons were 2-sided, and *P* values<0.05 were regarded as statistically significant. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 22.0 (IBM Corporation, Armonk, NY).

RESULTS

Natural Course of POAF and Predictors for AF Recurrence

A total of 322 688 patients had undergone major or minor noncardiac surgeries under general or local anesthesia at our center during the study period; out of them, 1857 (0.6%) had new-onset POAF, and after applying the exclusion criteria, 411 (0.13%) patients had new-onset POAF and returned to sinus rhythm. After additional exclusion of those without regular ECG follow-up, a total of 315 patients were finally included in the analysis (Figure 1). Preoperative echocardiography was performed in 293 (93.0%) patients 8 days (median) before the index surgical procedure. The specific types of noncardiac surgery are listed in Table S2. POAF occurred within a median of 1 day from surgery, and 71.7% of the POAF cases developed within 2 days after the index surgery.

The study population underwent a median of 3 ECGs during the follow-up period (Table S1), and 293 (93.0%) patients received at least 1 electrocardiographic surveillance within a year after index discharge. Among the 315 patients with new-onset POAF, 53 (16.8%) showed recurrence of AF at a median follow-up of

24 months (interquartile range, 6.9–24.0). The cumulative incidence of AF recurrence during 2 years was 22.5% (Figure 2). Compared with those who did not have recurrent AF, patients with recurrent AF were more likely to have underlying hypertension (48.1% versus 69.8%; *P*=0.004), vascular disease (10.3% versus 22.6%; *P*=0.01) and had higher CHA_2DS_2-VASc scores (2.2 versus 2.9; *P*=0.007) (Table 1). In the multivariable analysis, independent predictive factors for AF recurrence after discharge were moderate to severe left atrial enlargement (hazard ratio [HR], 2.33; 95% CI, 1.26–4.32; *P*=0.007), hypertension (HR, 2.12; 95% CI, 1.16–3.86; *P*=0.02) (Table 2).

Clinical Outcome of Recurrent AF and Anticoagulation Therapy

During follow-up, stroke or systemic embolism, major bleeding, and death occurred in 1.6%, 4.4%, and 29.5% of the study population, respectively. Clinical outcomes according to AF recurrence are shown in Figure 3. Compared with those without recurrent AF, patients with recurrent AF had significantly higher rates of thromboembolic events (11.2% versus 0.8%, *P*<0.001) (Figure 3A) and major bleeding (26.9% versus 4.1%; *P*<0.001) (Figure 3C). Thromboembolic events were especially more prevalent in patients with recurrent AF who did not receive anticoagulation (Figure 3B). Recurrent AF (HR, 18.91; 95% CI, 2.07–172.32; *P*=0.009) was predictive of a thromboembolic event with multivariable Cox regression analysis (Table 2). Predictive factors for major bleeding were recurrent AF (HR, 6.44; 95% CI, 2.21–18.81; *P*=0.001), estimated glomerular filtration rate <60 mL/min/1.73m^2 (HR, 4.62; 95% CI, 1.39–15.39; *P*=0.01). All-cause mortality was not significantly different according to AF recurrence (45.3% versus 30.5%; *P*=0.15) (Figure 3D), and the independent predictor for all-cause mortality was age (HR, 1.03; 95% CI, 1.01–1.05; *P*=0.01) (Table 2).

At discharge, 80 (25.4%) patients received anticoagulation therapy, 59 (73.8%) were prescribed with warfarin, and 20 (25.0%) were prescribed a direct oral anticoagulant (Table S3). In the overall patient cohort, anticoagulation therapy was not associated with significant differences in the rates of stroke or systemic embolism (1.4% versus 2.5%; *P*=0.95), major bleeding (11.1% versus 7.2%; *P*=0.96), and all-cause mortality (39.1% versus 32.1%; *P*=0.76) (Figure 4). Similar results were obtained in the analysis on 53 patients with recurrent AF, in whom anticoagulation therapy did not show a significant impact on the rates of thromboembolic events (5.0 % versus 13.0 %; *P*=0.68), major bleeding (42.9% versus 24.0%, *P*=0.76), and all-cause mortality (59.9% versus 37.5%; *P*=0.26) (Figure 5).

DISCUSSION

In this retrospective analysis on 315 patients who developed POAF after noncardiac surgery, we found that (1) AF recurred during long-term follow-up in a substantial portion of patients (16.8%); (2) recurrence of AF was significantly associated with a higher rate of clinical events such as thromboembolic events and major bleeding; and (3) anticoagulation therapy was not associated with significant differences in adverse clinical events, but its role in this patient population needs further well-designed prospective studies.

Natural Course of POAF

AF is common during the immediate postoperative period, and spontaneously resolves as the patient's condition stabilizes.[13] The incidence of POAF in the current study (0.31%) was lower than the previously reported rates, which ranged from 0.4% to 30%.[5,6,14,15] This low incidence of POAF stems from (1) the inclusion of all major and minor surgical procedures performed under general and local anesthesia; (2) the absence of systematic screening for AF during hospitalization; and (3) diagnosis based on the retrospective review of electrocardiography, which could

Table 2. Multivariable Cox Analyses for the Recurrence of AF, Major Bleeding, Thromboembolic Event, and All-Cause Mortality

Variable	HR (95% CI)	*P* Value
Recurrent of AF*		
Moderate to severe LAE (vs normal to mild LAE)	2.33 (1.26–4.32)	0.007
Hypertension	2.12 (1.16–3.86)	0.02
Vascular disease	1.88 (0.98–3.62)	0.06
Major bleeding event†		
Recurrent AF	6.44 (2.21–18.81)	0.001
Estimated GFR < 60 mL/min/1.73m^2	4.62 (1.39–15.39)	0.01
Age	0.95 (0.90–1.01)	0.09
Thromboembolic event‡		
Recurrent AF	18.91 (2.07–172.32)	0.009
CHA_2DS_2-VASc score	1.62 (0.97–2.69)	0.07
All-cause mortality§		
Age	1.03 (1.01–1.05)	0.01

AF indicates atrial fibrillation; GFR, glomerular filtration rate; HR, hazard ratio; and LAE, left atrial enlargement.

*Multivariable analysis was conducted with adjustment of the following variables; age, diabetes mellitus, congestive heart failure, prior stroke, and CHA_2DS_2-VASc score.

†Multivariable analysis was conducted with adjustment of the following variables; hypertension, diabetes mellitus, congestive heart failure, prior stroke, vascular disease, and anticoagulation therapy.

‡Multivariable analysis was conducted with adjustment of the following variables; anticoagulation therapy, moderate to severe LAE, and estimated GFR.

§Multivariable analysis was conducted with adjustment of following variables: hypertension, diabetes mellitus, congestive heart failure, prior stroke, vascular disease, estimated GFR, anticoagulation therapy, and recurrent AF.

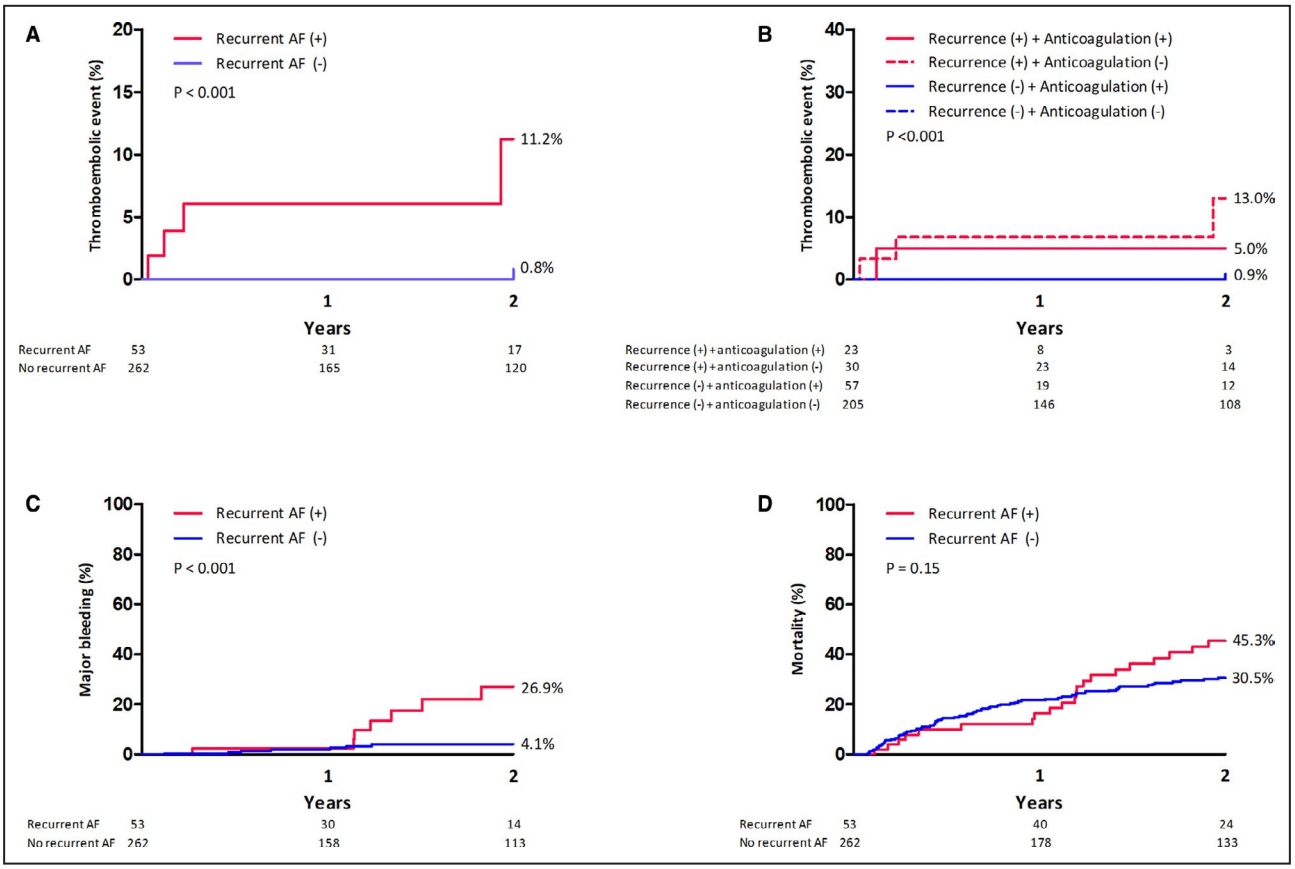

Figure 3. Kaplan–Meier curves of clinical events according to the recurrence of AF.
(**A**) Thromboembolic event, (**B**) thromboembolic event with anticoagulation, (**C**) major bleeding, (**D**) all-cause mortality. AF indicates atrial fibrillation.

have missed brief episodes of POAF. Nevertheless, we believe that our results are clinically relevant, as all ECGs and clinical outcomes were manually adjudicated by cardiologists, which is fundamentally different from the code-based diagnosis used in previous large cohort studies. The incidence and correlates of POAF should be further evaluated in a larger, prospective registry.

The long-term recurrences of POAF are reported to be as high as 20% to 37.3%.[4,16] Considering our current results, POAF may not be transient in some patients, especially in those with moderate to severe left atrial enlargement, hypertension, and vascular disease. As these factors are known predictors of spontaneous AF in the general population, we suppose that POAF develops in patients with atrial substrates upon triggering by surgical stress.[17]

Anticoagulation in Patients With POAF

In our study, the overall cumulative incidence of thromboembolic events in patients with POAF after noncardiac surgery was 2.4% during 2 years of follow-up irrespective of anticoagulation, which is comparable to the results from previous studies.[4,18–20] The current guidelines for anticoagulation strategy for new-onset POAF are based on the CHA_2DS_2-VASc score, but specific data regarding POAF after noncardiac surgery are lacking.[7,8,15,21] Makhija et al showed that anticoagulation did not significantly reduce the incidence of stroke (0.56% in nonanticoagulated patients versus 2.2% in anticoagulated patients) during a median follow-up of 27.6 months.[19] In contrast, a recent study based on the Danish national registry suggested that oral anticoagulation therapy significantly reduces the risks of thromboembolic events and mortality.[15] Such disparity might have stemmed from differences in the study design, subjects, and data source. Our data are in line with the former clinical data, as anticoagulation therapy was not associated with significant differences in clinical outcomes even in patients with recurrent AF. This may suggest that patients with anticoagulation might have had higher risk for ischemic stroke, and those without anticoagulation might have had higher risk for bleeding events. The uneven patient characteristics might have resulted in similar (statistically not different) clinical outcomes between those with versus without anticoagulation. Nevertheless,

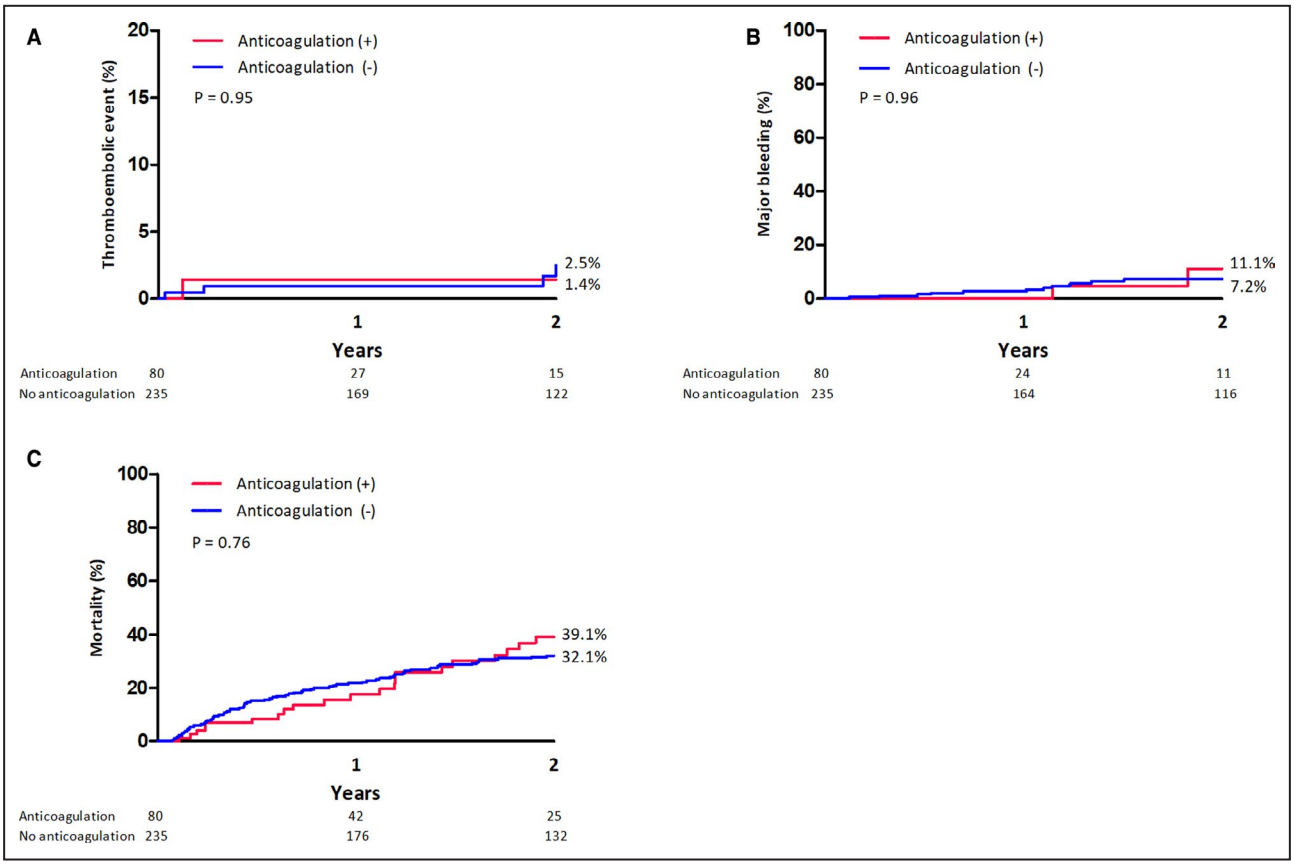

Figure 4. Kaplan–Meier curves of clinical events according to anticoagulation therapy in the whole patient cohort (n=315). (**A**) Thromboembolic event, (**B**) major bleeding, (**C**) all-cause mortality.

we still believe that the patients with recurrent AF may be considered as candidates for anticoagulation because (1) they have more comorbidities, especially the components of the CHA_2DS_2-VASc score; (2) they have more thromboembolic and bleeding events; and (3) the rate of thromboembolic events was numerically low in anticoagulated patients with recurrent AF (5.0% versus 13.0%), albeit without statistical significance. These findings show that patients with recurrent AF are fundamentally a high-risk group and that meticulous efforts should be made to find subclinical AF in this group. In contrast, regarding an almost negligible event rate in those without AF recurrence, anticoagulation may be deferred in patients without recurrence. Nevertheless, similar to our study results, previous data consistently showed that patients with POAF are exposed to higher risk of adverse outcomes including stroke, myocardial infarction, and death.[5,6] Therefore, further studies to reduce adverse clinical events in these high-risk patients should be attempted.

Clinical Impact of Recurrent POAF

POAF is generally regarded as a transient event that spontaneously reverts to sinus rhythm.[13] However, considering our result that recurrent AF was associated with a higher risk of clinical events in the long-term, some patients with POAF may be at high risk, and their condition should be regarded as spontaneous (or primary) AF. Recurrence of AF was a crucial factor for future ischemic events from the study result and our study has value in that probable benefit of anticoagulation therapy may possibly be offset by bleeding risk in a selected group of patients (postsurgical population) with recurrent AF because of higher risk of bleeding. It is possible that AF itself could have played a role in the development of clinical events and poorer outcomes, but baseline comorbidities, underlying cardiomyopathy, and left atrial remodeling might have also contributed to the higher rate of thromboembolic events.[22] The latter explanation is supported by a previous report showing the lack of temporal association between AF events and thromboembolic events.[23] Whether the association between AF and thromboembolism is direct or indirect, recurrent AF appears to be a clinically useful marker for defining the high-risk patient group that may be considered for standard anticoagulation therapy. As the incidence of thromboembolic events was low during the first year in this study, efforts for identifying AF recurrence may be more important than

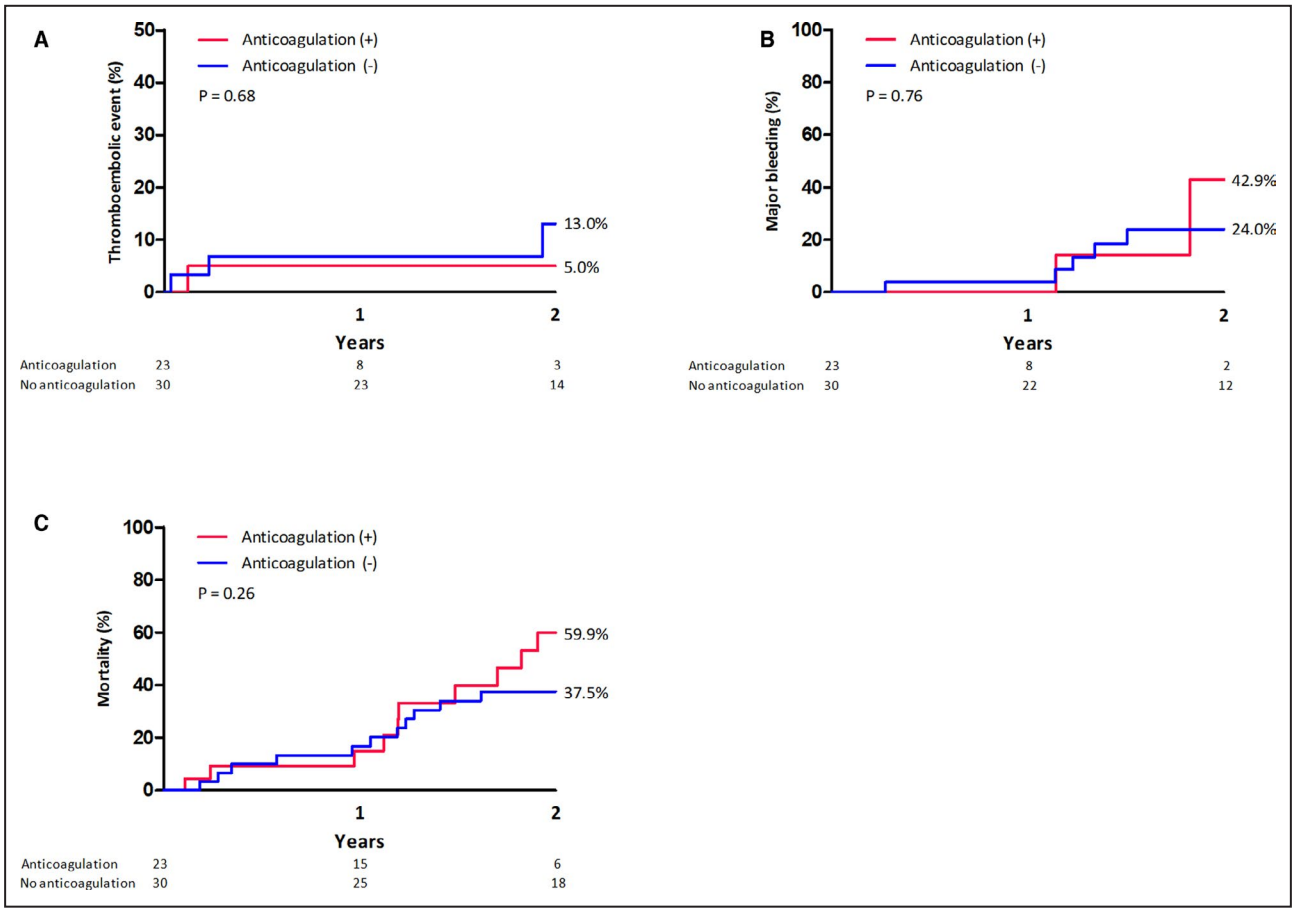

Figure 5. Kaplan–Meier curves of clinical events according to anticoagulation therapy in patients with recurrent AF (n=53). (**A**) Thromboembolic event, (**B**) major bleeding, (**C**) all-cause mortality. AF indicates atrial fibrillation.

treating all patients with routine anticoagulation. Further prospective study is needed to define a subgroup that can benefit from anticoagulation therapy than bleeding risks in this postsurgical population.

LIMITATIONS

Our study has several limitations. First, the number of patients with POAF is not large enough for a wide generalization of the study findings. Similarly, because of the small number of patients with recurrent AF, we could not highlight a specific group of patients who may potentially benefit from receiving anticoagulation therapy. This is reflected in the lack of statistically significant differences in thromboembolic or bleeding events among patients with AF recurrence or difference between anticoagulation versus no anticoagulation groups. Second, as the current study is retrospective in nature, clinical and electrocardiographic follow-up of the patients were not carried out in a uniform manner, which might have affected the detection rate of recurrence according to the rhythm monitoring strategy (intensity). The detection rate of POAF also might have been affected by the discrepancies in the duration of hospitalization as well as the duration and method of postoperative monitoring resulting from the difference in the types of surgical procedures. Moreover, POAF might have been overlooked in cases with no or minimal AF-related symptoms. Additional regression analysis was performed for implication of frequency of follow-up rhythm monitoring on the detection of recurrent AF, which showed that frequent monitoring was predictive of recurrence (HR, 1.80; 95% CI, 1.45–2.23; $P<0.001$). It might be reflective of (1) selection bias—patients with more frequent surveillance for recurrent AF were found to have higher recurrence; and (2) consequence of practice pattern—patients with recurrent AF had more symptoms or other signs that led physicians to perform more intense monitoring. This issue will be clarified only by prospective randomized clinical trials. Either way, more effort should be warranted to detect clinical evidence of recurrence in this population because of higher risk for adverse clinical events in those with AF recurrence. Third, the rates of all-cause mortality and major bleeding during 2-year follow-up were relatively higher than previously reported,[24] which may reflect the possible selection bias that high-risk patients after complex surgical procedures were included.

In this regard, generalization or interpretation of our findings should be carried out with caution. Furthermore, anticoagulation therapy did not affect bleeding events on regression analyses, which may also reflect the fact that selected patients with relatively low-risk features might have received anticoagulation therapy while patients with a high risk of bleeding might have been excluded from anticoagulation. Fourth, higher risk of major bleeding events in those with recurrent AF might have been affected by higher antiplatelet therapy compared with those without recurrent AF.

CONCLUSIONS

AF recurred in 16.8% of patients with POAF after noncardiac surgery, and the recurrence was associated with higher risks of thromboembolic events and major bleeding. Considering the relatively low risk for thromboembolic events and a high risk for bleeding events, routine anticoagulation in POAF should be carefully determined in such patients. Active surveillance for monitoring AF recurrence is warranted, and the role of anticoagulation needs to be further investigated.

ARTICLE INFORMATION

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Affiliation

From the Department of Cardiology, Heart Institute, Asan Medical Center, University of Ulan College of Medicine, Seoul, South Korea.

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Author contributions: Study design: J.H., M.S.C., and G.B.N.; data acquisition: J.H. and M.S.C.; data analysis and interpretation: all authors; manuscript drafting: J.H., M.S.C., and G.B.N.; critial revision of manuscript: all authors.

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Disclosures

None.

Supplementary Material

Tables S1–S3

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Supplemental Material

Table S1. Clinical details of rhythm monitoring during in-hospital period and after discharge.

In-hospital surveillance	No. of patients (%)	Median day (IQR)
Continuous monitoring using telemetry	96 (30.5)	12 (7–24)
Regular electrocardiographic surveillance	96 (30.5)	5 (3–7)
Electrocardiography when clinically needed	123 (39.0)	3 (2–4)

IQR, interquartile range.

Mode of rhythm monitoring after discharge	No. of patients (%)	Median (IQR)
Regular electrocardiographic surveillance	315 (100)	3 (1–5)
Time from discharge to first follow-up ECG		20 (10–57)
Frequency of follow-up ECG (ECGs per month)		0.2 (0.1–0.5)
Holter monitoring	33 (10.5)	
Duration of follow-up		545 ± 260

IQR, interquartile range.

Mode of rhythm monitoring after discharge	Overall N=315	Recurrent AF N=53	No recurrence N=262
Proportion of holter monitoring, n (%)	33 (10.5)	13 (24.5)	20 (7.6)
	Holter + ECG N = 33	ECG only N= 282	
Recurrent AF, n (%)	13 (39.4)	40 (14.2)	

Table S2. Clinical details on the type of non-cardiac surgery.

Type of Surgery		No. of patients (%)
Intra-peritoneal		137 (43.5)
	Hepatopancreatobiliary surgery	77 (24.4)
	Liver transplantation	46 (14.6)
	Liver resection	14 (4.4)
	Pancreaticoduodenectomy	13 (4.1)
	Resection of bile duct or gall bladder	4 (1.3)
	Alimentary tract surgery	41 (13.0)
	Colon resection or repair	16 (5.1)
	Gastrectomy, partial or total	16 (5.1)
	Small bowel resection or repair	9 (2.9)
	Other surgery involving peritoneum	1 (0.3)
	Urinary surgery	18 (5.7)
	Bladder resection or repair	10 (3.2)
	Nephrectomy	3 (1.0)
	Prostatectomy	2 (0.6)
	Kidney transplantation	3 (1.0)
Intra-thoracic		69 (21.9)
	lung resection	41 (13.0)
	esophagectomy	24 (7.6)
	Drainage of mediastinum	2 (0.6)
	Thymectomy	2 (0.6)
Orthopedic		53 (16.8)
	Spine surgery	19 (6.0)
	Hip replacement or arthroplasty	7 (2.2)
	Knee replacement or arthroplasty	11 (3.5)
	Open reduction of femur fracture	4 (1.3)
	Debridement or drainage of extremity	4 (1.3)
	Amputation of extremity	4 (1.3)
	Fasciotomy	3 (1.0)
	Open reduction of pelvic bone	1 (0.3)
Neurosurgery		22 (7.0)
	Clipping of aneurysm	10 (3.2)
	Resection of brain tumor	6 (1.9)
	Biopsy of brain	2 (0.6)
	Burr hole surgery	2 (0.6)
	Incision and drainage of brain abscess	1 (0.3)
	Resection of pituitary tumor	1 (0.3)
Vascular		18 (5.7)

	Aorta replacement surgery	12 (3.8)
	Arteriovenous fistula formation	3 (1.0)
	Carotid endarterectomy	2 (0.6)
	Arterial thrombectomy	1 (0.3)
Head and neck		11 (3.5)
	Incision and drainage of deep neck infection	4 (1.3)
	thyroidectomy	1 (0.3)
	Tracheal resection	1 (0.3)
	Surgery involving pharynx or tongue	1 (0.3)
	Surgery involving nasal cavity	1 (0.3)
	Surgery involving larynx	1 (0.3)
	Excisional biopsy of lymph node	1 (0.3)
	Mandibulectomy	1 (0.3)
Obstetric and gynecologic		4 (1.3)
	Hysterectomy	2 (0.6)
	Resection of ovarian tumor	1 (0.3)
	Vulvar mass excision	1 (0.3)
Other		1 (0.3)
	Vitrectomy	1 (0.3)

Table S3. Type of medication among those who received anticoagulation therapy (n=80).

Type of anticoagulation	No. of patients (%)
Total	80 (100)
Warfarin	59 (73.8)
Direct oral anticoagulant	20 (25.0)
Dabigatran	4 (5.0)
Rivaroxaban	12 (15.0)
Apixaban	3 (3.8)
Edoxaban	1 (1.3)
Low-molecular weight heparin	1 (1.3)