Journal of Cardiology 74 (2019) 488–493

Contents lists available at ScienceDirect

Journal of Cardiology

journal homepage: www.elsevier.com/locate/jjcc

Original article

The relationship between decreased pulmonary function and atrial fibrillation in general population: Findings from Ansung–Ansan cohort of the Korean Genome and Epidemiology Study☆

Byung Sik Kim (MD)[a,1], Jin-Kyu Park (MD, PhD)[a,1], Yonggu Lee (MD, PhD)[b], Jeong Hun Shin (MD, PhD)[b], Young-Hyo Lim (MD, PhD)[a], Hwan-Cheol Park (MD, PhD)[b], Chun Ki Kim (MD)[c], Jinho Shin (MD, PhD)[a,*]

[a] Division of Cardiology, Department of Internal Medicine, Hanyang University Medical Center, Seoul, Republic of Korea
[b] Division of Cardiology, Department of Internal Medicine, Hanyang University Guri Hospital, Guri City, Gyounggi-do, Republic of Korea
[c] Department of Nuclear Medicine, Hanyang University Medical Center, Seoul, Republic of Korea

ARTICLE INFO

Article history:
Received 27 March 2019
Received in revised form 30 April 2019
Accepted 13 May 2019
Available online 25 June 2019

Keywords:
Atrial fibrillation
Pulmonary function
Spirometry
General population

ABSTRACT

Background: Decreased pulmonary function is a possible risk factor for atrial fibrillation (AF). However, data on this relationship in Asian populations are scant. The aim of this study was to evaluate the relationship between decreased pulmonary function and the incidence of AF in a prospective cohort of Koreans aged 40–69 years.

Methods: We assessed AF in 9631 Korean people enrolled in the community-based cohort who were followed for up to 12 years. AF at baseline was identified by electrocardiography (ECG) performed during the baseline visit and/or the self-reported history of physician-determined diagnosis made before the baseline visit. Similarly, AF newly developed after the baseline visit was also identified by biennially performed ECGs and/or the self-reported history of physician-determined diagnosis that occurred between each biennial visit. If AF was identified by both ECGs and the history in the same subject, the earlier identification date was considered the time of AF development.

Results: The median age was 50 (interquartile range, 44–60) years, and 4633 (48.1%) were male. The prevalence of AF at baseline was significantly higher in subjects with lower quartiles of forced expiratory volume in second (FEV_1)% predicted (1.2% in the lowest quartile versus 0.3% in the highest quartile; $p < 0.001$). After adjustment for cardiovascular risk factors, FEV_1% predicted and forced vital capacity (FVC)% predicted were independent risk factors for AF at baseline. Over a median follow-up period of 138 (interquartile range, 70–141) months, AF was newly documented in 162 subjects (1.7%). The lowest quartiles of FEV_1% predicted (adjusted hazard ratio, 1.59; 95% confidence interval, 1.02–2.50) was associated with a higher risk of incident AF than the highest quartiles.

Conclusions: In this large community-based cohort study with a long-term follow-up, decreased pulmonary function was found to be an independent risk factor for AF in the general Korean population.

Introduction

Atrial fibrillation (AF), the most common arrhythmia, increases the risk of stroke fivefold and the risk of cardiac failure threefold, which leads to an increase in mortality rate [1]. Previous studies identified many risk factors for the development of AF, including age, obesity, smoking, alcohol consumption, hypertension, diabetes, ischemic heart disease, congestive heart disease, valvular heart disease, obstructive sleep apnea, vigorous physical activity, and chronic obstructive pulmonary disease (COPD) among others [2]. However, not all patients with AF have these risk factors [3]. In addition to the well-known risk factors mentioned above, several studies have shown the association between pulmonary function and the incidence of AF in the general population [4,5]. However, these studies were mainly conducted on subjects from Western countries. While there has been a cross-sectional study on this

DOI of commentary article: https://doi.org/10.1016/j.jjcc.2019.06.009.
* Corresponding author at: Hanyang University Medical Center, Sungdong-gu, Wangsipriro 222, Seoul 04763, Republic of Korea.
E-mail address: jhs2003@hanyang.ac.kr (J. Shin).
[1] Byung Sik Kim and Jin-Kyu Park contributed equally to this work.

https://doi.org/10.1016/j.jjcc.2019.05.014
0914-5087/

topic from an Asian country [6], no study using a prospective Asian cohort has been published. Therefore, this study aimed to investigate the association of decreased pulmonary function with AF in an Asian population based on Korean subjects who participated in a community-based cohort.

Materials and methods

Study population

We analyzed data from the Ansung–Ansan cohort, which is a prospective study population that consists of South Koreans aged 40–69 years residing in two cities, Ansung and Ansan. This study was started in 2001 and embedded within the Korean Genome and Epidemiology Study (KoGES), a population-based cohort study, to assess the incidence of and risk factors for various chronic disorders including cardiopulmonary diseases.

The initial baseline survey, conducted from 2001 to 2002, included 10,030 adults. Of the 10,030 subjects, 399 subjects were excluded due to missing spirometry data. The remaining 9631 subjects (4633 males and 4998 females) were finally included in the study. Following the baseline visit, 9631 subjects were examined biennially with the longest follow-up duration being 12 years. At each of the baseline and biennial visits, data on lifestyle characteristics, cardiovascular profiles, medical history, and disease incidence were collected. All tests and interview-based surveys were conducted by health professionals who were trained to follow a standardized protocol, and the same instruments were used to collect the data. The detailed information regarding the enrollment of cohort members and study procedures is available in a previous report [7].

The study protocol was approved by the Ethics Committee of KoGES at the Korean National Institute of Health and adhered to the principles of the Declaration of Helsinki. In addition, this study was approved by the Institutional Review Board of Hanyang University Medical Center. Informed consent was obtained from all participants.

Measurement of laboratory data

A comprehensive metabolic panel to measure glucose, triglyceride, total cholesterol, triglyceride, high-density lipoprotein (HDL)-cholesterol, and serum creatinine was performed after an overnight fast using a Hitachi 747 chemistry analyzer (Hitachi Ltd., Tokyo, Japan). Low-density lipoprotein (LDL)-cholesterol levels were calculated using the Friedewald formula [8]. White blood cell (WBC) counts were measured using an autoanalyzer (Sysmex, Kobe, Japan). The circulating concentration of C-reactive protein (CRP) was measured by immunoradiometric assay (ADVIA 1650, Bayer Diagnostics, Tarrytown, NY, USA).

Spirometry

Spirometry was measured by three well-trained pulmonary technologists in concordance with the 1994 American Thoracic Society recommendation [9], using a spirometer (Vmax-229, Sensor-Medics, Yorba Linda, CA, USA) for all subjects. The predicted forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were measured using a standardized method.

Analysis of electrocardiography and assessment of AF

All participants underwent 12-lead electrocardiography (ECG) during each of baseline and biennial follow-up visits using the GE Marquette MAC 5000® (GE Marquette Inc., Milwaukee, WI, USA) in a supine position during quiet respiration at rest. ECGs were recorded in a 25 mm/s and 0.1 mV/mm standardization and interpreted by a cardiologist. AF at baseline was identified by ECG performed during the baseline visit and/or the self-reported history of physician-determined diagnosis made prior to the baseline visit. Similarly, AF newly developed after the baseline visit was also identified by biennially performed ECGs and/or the self-reported history of physician-determined diagnosis that occurred between each biennial visit. If AF was identified by both ECGs and the history in the same subject, the earlier identification date was considered the time of AF development.

Statistical analysis

All continuous variables were reported as a median and interquartile range (IQR), and categorical variables were presented as numbers and percentages. Kruskal–Wallis test was used to compare continuous variables between groups. The Chi-square test was used for categorical variables. Logistic regression was used for cross-sectional analysis of the prevalence of AF at baseline in relation to quartiles of FEV_1% predicted and FVC% predicted. After excluding subjects who were identified to have AF at the baseline visit, the incidence of AF newly developed during the follow-up period was analyzed according to quartiles of FEV_1% predicted and FVC% predicted. We computed Kaplan–Meier curves of cumulative incidence of AF by quartiles of FEV_1% predicted and FVC% predicted. Hazard ratios and 95% confidence intervals of AF by quartiles of FEV_1% predicted and FVC% predicted with the highest quartile as reference were obtained using Cox proportional hazard models. Risk factors for AF [1,2,10] such as age, sex, body mass index, hypertension, diabetes, myocardial infarction, alcohol, and smoking (pack-years) were used as covariates for adjustment in the logistic regression and Cox proportional hazard models. For all assessments, a p-value < 0.05 was considered statistically significant. Statistical analysis was performed using PASW 18.0 (SPSS, Chicago, IL, USA).

Results

Baseline characteristics

A total of 9631 participants (male, 48.1%; median age, 50 [IQR, 44–60] years) were followed up for 138 (IQR, 70–141) months. Baseline characteristics according to quartiles of FEV_1% predicted are shown in Table 1. In the lowest quartile of FEV_1% predicted, the median age of subjects was lower, there were more male subjects, and the overall education level of subjects was higher than in the highest quartile of FEV_1% predicted. The frequencies of diabetes mellitus, hyperlipidemia and COPD were higher in subjects in the lowest quartile of FEV1% predicted. There were significantly more current or former smokers in the lowest quartile of FEV_1% predicted. Pack-years of cigarette smoking and the amount of alcohol intake were higher in subjects in the lowest quartile of FEV_1% predicted compared to those in the highest quartile of FEV_1% predicted. WBC counts and CRP levels were significantly higher in subjects in the lowest quartile of FEV_1% predicted.

AF at baseline was identified in 59 of 9631 (0.6%) subjects. The prevalence of AF was highest in subjects in the lowest quartile of FEV_1% predicted at baseline (1.2% versus 0.3% of subjects in the highest quartile; $p < 0.001$). Baseline characteristics according to quartiles of FVC% predicted also showed similar findings (Supplementary Table 1).

Pulmonary function and risk of AF at baseline

At baseline, the risk of AF was significantly higher in subjects in the lowest quartile of FEV_1% predicted than the subjects in highest

Table 1
Baseline characteristics according to quartiles of FEV_1% predicted.

	FEV_1% predicted					
	Total 112 (101–123) (*n* = 9631)	Quartile 1 93 (85–97) (*n* = 2363)	Quartile 2 106 (104–109) (*n* = 2394)	Quartile 3 117 (114–120) (*n* = 2411)	Quartile 4 131 (126–139) (*n* = 2463)	*p*-Value
Age (years)	50.0 (44.0–60.0)	50.0 (44.0–60.0)	48.0 (43.0–57.0)	49.0 (44.0–58.0)	55.5 (46.0–62.0)	<0.001
Male	4633 (48.1%)	1553 (65.7%)	1330 (55.6%)	1044 (43.3%)	706 (28.7%)	<0.001
Education						<0.001
Lower than high school	5362 (56.0%)	1252 (23.3%)	1135 (21.2%)	1301 (24.3%)	1674 (31.2%)	
High school	2939 (30.7%)	725 (24.7%)	846 (28.8%)	785 (26.7%)	583 (19.8%)	
University and college	1279 (13.4%)	373 (29.2%)	404 (31.6%)	312 (24.4%)	190 (14.9%)	
Height (cm)	160.0 (153.5–167.0)	163.2 (156.7–168.5)	162.1 (155.2–168.0)	159.5 (153.7–166.0)	155.2 (150.2–162.0)	<0.001
Weight (kg)	62.2 (56.0–70.0)	64.0 (57.3–71.7)	64.0 (57.3–71.0)	62.0 (56.0–70.0)	59.4 (54.0–65.9)	<0.001
Body mass index (kg/m^2)	24.5 (22.5–26.5)	24.4 (22.2–26.5)	24.5 (22.7–26.7)	24.6 (22.6–26.6)	24.4 (22.5–26.3)	0.046
Hypertension	1481 (15.4%)	396 (16.8%)	345 (14.4%)	346 (14.4%)	394 (16.0%)	0.049
Diabetes mellitus	645 (6.7%)	186 (7.9%)	164 (6.9%)	156 (6.5%)	139 (5.6%)	0.020
Hyperlipidemia	234 (2.4%)	75 (3.2%)	46 (1.9%)	64 (2.7%)	49 (2.0%)	0.014
Congestive heart failure	23 (0.2%)	4 (0.2%)	6 (0.3%)	6 (0.2%)	7 (0.3%)	0.869
Coronary artery disease	77 (0.8%)	26 (1.1%)	11 (0.5%)	22 (0.9%)	18 (0.7%)	0.081
Previous myocardial infarction	94 (1.0%)	33 (1.4%)	22 (0.9%)	15 (0.6%)	24 (1.0%)	0.057
Peripheral artery disease	35 (0.4%)	8 (0.3%)	8 (0.3%)	7 (0.3%)	12 (0.5%)	0.683
Cerebrovascular disease	103 (1.1%)	30 (1.3%)	27 (1.1%)	23 (1.0%)	23 (0.9%)	0.636
Chronic obstructive pulmonary disease	62 (0.6%)	27 (1.1%)	17 (0.7%)	13 (0.5%)	4 (0.2%)	0.001
Thyroid disease	294 (3.1%)	60 (2.5%)	76 (3.2%)	81 (3.4%)	77 (3.1%)	0.386
Chronic kidney disease (stage ≥3)	758 (7.9%)	190 (8.0%)	139 (5.8%)	175 (7.3%)	254 (10.3%)	<0.001
Cigarette smoking status						<0.001
Ever smoker						
Current smoker	2500 (26.0%)	916 (38.8%)	696 (29.1%)	521 (21.6%)	367 (14.9%)	
Former smoker	1510 (15.7%)	452 (29.9%)	450 (18.8%)	349 (14.5%)	259 (10.5%)	
Never smoker	5621 (58.4%)	995 (42.1%)	1248 (52.1%)	1541 (63.9%)	1837 (74.6%)	
Pack years in smoker	20.0 (10.0–30.0)	22.5 (12.5–36.2)	20.0 (10.8–30.0)	20.0 (10.0–30.0)	20.0 (10.0–30.0)	<0.001
Amount of alcohol (g/day)	11.4 (2.9–31.0)	16.4 (4.2–37.3)	11.6 (3.3–33.3)	9.8 (2.7–28.9)	7.3 (2.1–23.2)	<0.001
White blood cell ($\times 10^3/mm^3$)	6.3 (5.3–7.5)	6.6 (5.6–7.8)	6.4 (5.4–7.6)	6.3 (5.3–7.4)	6.1 (5.1–7.2)	<0.001
C-reactive protein (mg/dl)	0.14 (0.07–0.25)	0.15 (0.07–0.28)	0.14 (0.07–0.25)	0.14 (0.07–0.24)	0.14 (0.07–0.23)	<0.001
Atrial fibrillation at baseline	59 (0.6%)	29 (1.2%)	14 (0.6%)	9 (0.4%)	7 (0.3%)	<0.001

Data shown with percentages in parentheses represent numbers of participants, and other data represent median values with interquartile ranges in parentheses.
FEV_1, forced expiratory volume in one second.

quartile of FEV_1% predicted at baseline (adjusted OR, 5.92; 95% CI, 2.22–15.77; Table 2). Similar results were observed regarding the association between the risk of AF and FVC% predicted at baseline (adjusted OR, 5.40; 95% CI, 2.06–14.20). The association between FEV_1/FVC lower than 0.7 and risk of AF was no longer found to be significant after adjustment (adjusted OR, 1.34; 95% CI, 0.64–2.81).

Pulmonary function and incidence of AF

Newly developed AF was identified in 162 subjects (1.7%) during the follow-up period. Kaplan–Meier curves for the cumulative incidence of AF according to quartiles of FEV_1% predicted and FVC% predicted are shown in Fig. 1. The incidence of AF was significantly higher in subjects in the lowest quartile of FEV_1% predicted (2.1% vs. 1.5%; log rank $p = 0.042$) compared to those in the highest quartile. However, there was no significant association between the incidence of AF and quartiles of FVC% predicted. In Cox regression analyses, as shown in Table 3, subjects with the lowest quartile of FEV_1% predicted had a higher risk of incident AF compared to subjects with the highest quartile of FEV_1% predicted after adjustment for covariates (adjusted HR, 1.59; 95% CI, 1.02–2.50). The incidence of AF was not significantly higher in subjects with the lowest FVC% predicted (adjusted HR, 1.34; 95% CI, 0.86–2.09) compared to those with the highest FVC% predicted. Moreover, the association between $FEV_1/FVC < 0.7$ and incident AF was no longer significant after adjustment.

Table 2
Risk of atrial fibrillation at baseline according to pulmonary function.

	Non-adjusted OR (95% CI)	*p*-Value	*p*-Value for trend	Adjusted OR[a] (95% CI)	*p*-Value	*p*-Value for trend
FEV_1% predicted			<0.001			<0.001
Quartile 1	4.36 (1.91–9.97)	<0.001		5.92 (2.22–15.77)	<0.001	
Quartile 2	2.06 (0.83–5.12)	0.118		3.26 (1.15–9.24)	0.027	
Quartile 3	1.32 (0.49–3.54)	0.588		2.06 (0.69–6.22)	0.198	
Quartile 4	1			1		
FVC% predicted			<0.001			<0.001
Quartile 1	5.77 (2.24–14.90)	<0.001		5.40 (2.06–14.20)	0.001	
Quartile 2	2.92 (1.06–8.04)	0.039		3.12 (1.12–8.70)	0.029	
Quartile 3	1.64 (0.55–4.89)	0.378		1.34 (0.42–4.25)	0.618	
Quartile 4	1			1		
$FEV_1/FVC < 0.7$	2.08 (1.05–4.12)	0.036		1.34 (0.64–2.81)	0.441	

[a] Adjusted for age, sex, body mass index, hypertension, diabetes, myocardial infarction, alcohol, and smoking (pack years).
FEV_1, forced expiratory volume in one second; FVC, forced vital capacity.

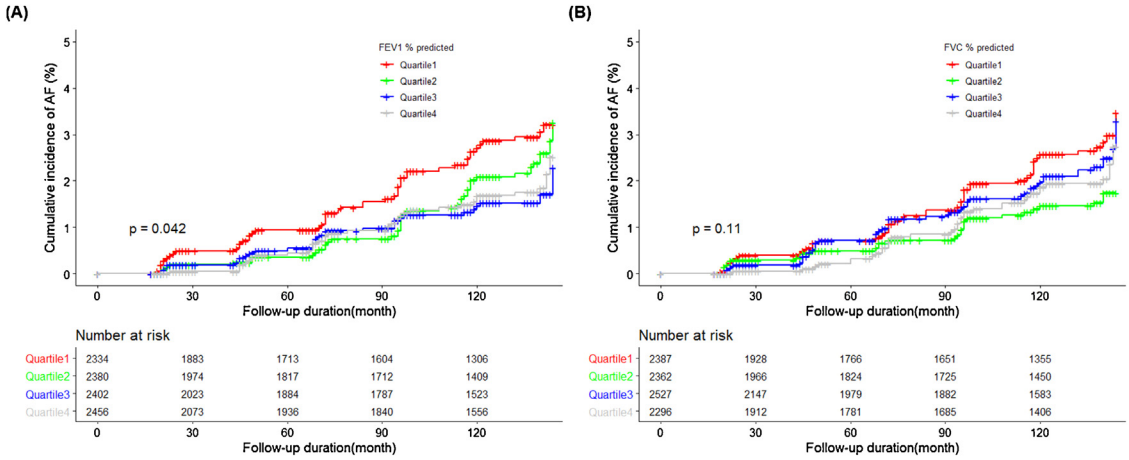

Fig. 1. Kaplan–Meier estimates of cumulative incidences of AF by quartiles of FEV_1% predicted (A) and FVC% predicted (B). *Abbreviations*: AF, atrial fibrillation; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity.

Table 3
Pulmonary function and risk of incident atrial fibrillation.

	Non-adjusted HR (95% CI)	*p*-Value	*p*-Value for trend	Adjusted HR[a] (95% CI)	*p*-Value	*p*-Value for trend
FEV_1% predicted			0.012			0.017
Quartile 1	1.59 (1.04–2.43)	0.034		1.59 (1.02–2.50)	0.041	
Quartile 2	1.27 (0.82 –1.97)	0.290		1.41 (0.89–2.23)	0.139	
Quartile 3	0.89 (0.56–1.43)	0.630		0.99 (0.62–1.60)	0.979	
Quartile 4	1			1		
FVC% predicted			0.415			0.416
Quartile 1	1.35 (0.88–2.08)	0.168		1.34 (0.86–2.09)	0.190	
Quartile 2	0.78 (0.48–1.27)	0.323		0.86 (0.52–1.41)	0.542	
Quartile 3	1.18 (0.77–1.81)	0.457		1.24 (0.80–1.91)	0.340	
Quartile 4	1			1		
$FEV_1/FVC < 0.7$	2.01 (1.31–3.11)	0.002		1.33 (0.83–2.14)	0.235	

[a] Adjusted for age, sex, body mass index, hypertension, diabetes, myocardial infarction, alcohol, and smoking (pack years).
FEV_1, forced expiratory volume in one second; FVC, forced vital capacity.

Discussion

In this large population-based cohort study, we found that subjects with lower FEV_1% and FVC% predicted values had higher risks of AF at baseline. Furthermore, the incidence of newly developed AF was also significantly higher in subjects with lower FEV_1% predicted values than in those with higher FEV_1% predicted values at up to 12 years' follow-up. To the best of our knowledge, this is the first study using a large prospective cohort which investigates the association between reduced pulmonary function and the development of AF in an Asian population. A multiethnic study was conducted by Chahal et al. [5]. However, only approximately 10% of the study population were Asians, and no subgroup analysis was performed. In Japan, Shibata et al. reported a cross-sectional study of the relationship between reduced pulmonary function and AF prevalence [6]. Recently, Liao et al. reported a prospective study in which the incidence of AF was higher in patients with COPD than in patients without COPD in an Asian population. However, the study did not include pulmonary function results and was not performed in a healthy population [11]. Liao et al.'s data provide evidence of a similar association in Asian populations. Our study corroborates previous studies conducted on a Western population which demonstrated that decreased pulmonary function is a risk factor for the development of AF. In the Malmo Preventive Project, the largest study on a Western population, Johnson et al. showed that decreased quartiles of FEV_1 and FVC were independent risk factors for AF [4]. In the Copenhagen City Heart Study, Buch et al. reported that reduced FEV_1% predicted value was an independent predictor of new-onset AF [12]. However, in these two previous studies, assessment of AF was made only in symptomatic patients either based on hospital admission with a diagnosis of AF [4,12] or a single ECG performed at 5 years after the initial visit [12]. On the other hand, our diagnosis of AF was made with ECG performed every 2 years regardless of being symptomatic or not and/or self-reported history of physician-determined diagnosis that occurred between each visit. Therefore, while asymptomatic AF that occurred during the study period may have been missed in both the previous studies and our study, we believe that our approach allowed for a more sensitive identification of AF in the general population.

In our study, the prevalence of AF at baseline and the incidence of subsequently developed AF were both significantly lower than of those in Western reports; this may reflect differences between the study populations. Indeed, a previous study also showed a relatively low prevalence of AF being 0.67% and the incidence per 10,000 person-years being 17.14 in the Korean population [13].

The mechanisms of reduced pulmonary function and AF are unclear. One possible hypothesis is that ectopic beats that initiate AF often originate from the pulmonary veins [14] and may be triggered by the alteration of hemodynamics such as pulmonary hypertension and hypoxia. Another possible mechanism is that impaired pulmonary function has been shown to be associated

with coronary artery disease [15] and metabolic syndromes such as hypertension and hyperlipidemia [16], which, in turn, may lead to a higher incidence of AF [17]. However, in our study, the relationship between reduced pulmonary function and AF was unchanged after adjusting for several cardiovascular risk factors.

Smoking was significantly associated with pulmonary function. The association between cigarette smoking and the incidence of AF was inconsistent in previous studies [18,19]. Many confounding factors may influence the establishment of a causal effect of smoking on the risk of AF in the general population. In a recent meta-analysis, current smokers and former smokers were associated with an increased risk of AF as compared with never smokers [20]. Two cross-sectional studies conducted on Asian populations showed different results. A Japanese study found a significant effect of smoking on the risk of AF [21], while a Chinese study did not [22]. Otherwise, no prospective studies have been conducted in Asian populations. Although detailed data were not presented in the Results section, we found a significant relationship between the smoking status and the incidence of AF. In the Kaplan–Meier curve for the cumulative incidence of AF by smoking status (Supplementary Fig. 1), ever smokers had a higher incidence of AF than never smokers (log rank $p = 0.045$). The inverse association between pulmonary function and the risk of AF was maintained even after being adjusted for smoking. Johnson et al. showed a similar result of consistent relationships in never smokers and smokers [4].

A possible role of systemic inflammation was also suggested in the pathogenesis of AF [23]. Elevated CRP levels and WBC counts were reported to be associated with the prevalence and incidence of AF [24,25]. Fogarty et al. showed that serum CRP level was inversely associated with lung function in a cross-sectional study [26]. Our study on the general Asian population also showed that inflammatory markers such as WBC and CRP are associated inversely with FEV_1% predicted, which supports previous results.

Anticholinergics, beta-agonists, and methylxanthines may be arrhythmogenic in patients with COPD. However, the prevalence of COPD was approximately 0.6% in the present study, and FEV_1/FVC, a more specific parameter for airway obstruction, failed to show a significant association in the present study. Further study is needed in a population with more patients with COPD or more severe airway obstruction.

Strengths and limitations

The strengths of our study include its large sample size and long-term follow-up. In addition, the quality of this study was enhanced by conducting a face-to-face interview at each examination, in strict observance of the standardized protocol. The risk of AF according to pulmonary function was adjusted for other known risk factors for AF. Furthermore, the key strength of our study is that it is the first large study using a prospective cohort in an Asian population on the relationship of reduced pulmonary function with the incidence of AF.

Our study has some limitations. While we tried to identify AF using both ECGs and self-reported history of physician-determined diagnosis, we could not obtain participants' International Classification of Disease (ICD) because ICD was considered protected personal information. Therefore, some paroxysmal AF that waxed and waned between each visit could still have been missed. Nonetheless, we believe that our approach still enabled us a reasonably sensitive identification of AF compared to other studies as discussed above.

Conclusions

As in the Western population, decreased pulmonary function is an independent risk factor for developing AF in the general Korean population. Therefore, subjects with pulmonary function lower than their predicted one may be potential candidates for the more meticulous screening of AF.

Funding

This work was supported by a grant from the National Research Foundation of Korea (https://www.nrf.re.kr/eng/main), which is funded by the Korean government (MSIP; Ministry of Science, ICT & Future Planning) (No. NRF-2017R1C1B5017115). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflict of interest

None.

Acknowledgments

The authors thank all the participants and research staff of the Institute of Human Genomic Study at Ansan Hospital of the Korea University.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jjcc.2019.05.014.

References

[1] January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland Jr JC, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol 2014;64:e1–76.
[2] Kirchhof P, Benussi S, Kotecha D, Ahlsson A, Atar D, Casadei B, et al. 2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS. Eur Heart J 2016;37:2893–962.
[3] Huxley RR, Lopez FL, Folsom AR, Agarwal SK, Loehr LR, Soliman EZ, et al. Absolute and attributable risks of atrial fibrillation in relation to optimal and borderline risk factors: the Atherosclerosis Risk in Communities (ARIC) study. Circulation 2011;123:1501–8.
[4] Johnson LS, Juhlin T, Engström G, Nilsson PM. Reduced forced expiratory volume is associated with increased incidence of atrial fibrillation: the Malmö Preventive Project. Europace 2013;16:182–8.
[5] Chahal H, Heckbert SR, Barr RG, Bluemke DA, Jain A, Habibi M, et al. Ability of reduced lung function to predict development of atrial fibrillation in persons aged 45 to 84 years (from the Multi-Ethnic Study of Atherosclerosis-Lung Study). Am J Cardiol 2015;115:1700–4.
[6] Shibata Y, Watanabe T, Osaka D, Abe S, Inoue S, Tokairin Y, et al. Impairment of pulmonary function is an independent risk factor for atrial fibrillation: the Takahata study. Int J Med Sci 2011;8:514–22.
[7] Kim Y, Han BG. Cohort profile: The Korean Genome and Epidemiology Study (KoGES) Consortium. Int J Epidemiol 2017;46:e20.
[8] Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 1972;18:499–502.
[9] Standardization of spirometry. 1994 update. American Thoracic Society. Am J Respir Crit Care Med 1995;152:1107–36.
[10] Shin J, Park JB, Kim KI, Kim JH, Yang DH, Pyun WB, et al. 2013 Korean Society of Hypertension guidelines for the management of hypertension: part III-hypertension in special situations. Clinical hypertension 2015;21(3).
[11] Liao KM, Chen CY. Incidence and risk factors of atrial fibrillation in Asian COPD patients. Int J Chron Obstruct Pulmon Dis 2017;12:2523–30.
[12] Buch P, Friberg J, Scharling H, Lange P, Prescott E. Reduced lung function and risk of atrial fibrillation in the Copenhagen City Heart Study. Eur Respir J 2003;21:1012–6.
[13] Lee S-R, Choi E-K. Prevalence of atrial fibrillation in Korean population. Int J Arrhythm 2017;18:195–204.
[14] Haissaguerre M, Jais P, Shah DC, Takahashi A, Hocini M, Quiniou G, et al. Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. N Engl J Med 1998;339:659–66.
[15] Schroeder EB, Welch VL, Couper D, Nieto FJ, Liao D, Rosamond WD, et al. Lung function and incident coronary heart disease: the Atherosclerosis Risk in Communities Study. Am J Epidemiol 2003;158:1171–81.

[16] Chen WL, Wang CC, Wu LW, Kao TW, Chan JY, Chen YJ, et al. Relationship between lung function and metabolic syndrome. PLoS One 2014;9:e108989.
[17] Schnabel RB, Yin X, Gona P, Larson MG, Beiser AS, McManus DD, et al. 50 year trends in atrial fibrillation prevalence, incidence, risk factors, and mortality in the Framingham Heart Study: a cohort study. Lancet 2015;386:154–62.
[18] Chamberlain AM, Agarwal SK, Folsom AR, Duval S, Soliman EZ, Ambrose M, et al. Smoking and incidence of atrial fibrillation: results from the Atherosclerosis Risk in Communities (ARIC) study. Heart Rhythm 2011;8:1160–6.
[19] Okumura Y. Smoking and the risk of the perpetuation of atrial fibrillation: under debate in large cohort studies. Heart Rhythm 2011;8:1167–8.
[20] Zhu W, Yuan P, Shen Y, Wan R, Hong K. Association of smoking with the risk of incident atrial fibrillation: a meta-analysis of prospective studies. Int J Cardiol 2016;218:259–66.
[21] Suzuki S, Sagara K, Otsuka T, Kano H, Matsuno S, Takai H, et al. Effects of smoking habit on the prevalence of atrial fibrillation in Japanese patients with special reference to sex differences. Circ J 2013;77:2948–53.
[22] Sun G-Z, Guo L, Wang X-Z, Song H-J, Li Z, Wang J, et al. Prevalence of atrial fibrillation and its risk factors in rural China: a cross-sectional study. Int J Cardiol 2015;182:13–7.
[23] Issac TT, Dokainish H, Lakkis NM. Role of inflammation in initiation and perpetuation of atrial fibrillation: a systematic review of the published data. J Am Coll Cardiol 2007;50:2021–8.
[24] Lee Y, Park H-C, Shin J-H, Lim Y-H, Shin J, Park J-K. Single and persistent elevation of C-reactive protein levels and the risk of atrial fibrillation in a general population: the Ansan–Ansung Cohort of the Korean Genome and Epidemiology Study. Int J Cardiol 2019;277:240–6.
[25] Rienstra M, Sun JX, Magnani JW, Sinner MF, Lubitz SA, Sullivan LM, et al. White blood cell count and risk of incident atrial fibrillation (from the Framingham Heart Study). Am J Cardiol 2012;109:533–7.
[26] Fogarty AW, Jones S, Britton JR, Lewis SA, McKeever T. Systemic inflammation and decline in lung function in a general population: a prospective study. Thorax 2007;62:515–20.