Prevalence and Predictors of Subclinical Atrial Fibrillation in Hypertensive Elderly Patients Using Ambulatory ECG Monitoring

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ABSTRACT

Background: Atrial fibrillation (AF) is the most prevalent sustained cardiac arrhythmia worldwide and a major independent risk factor for ischemic stroke, heart failure, and systemic embolism. Hypertensive elderly patients represent a high-risk population in whom subclinical AF frequently goes unrecognized. Extended home-based ambulatory ECG monitoring improves detection but faces practical barriers in resource-limited outpatient settings. Single-session ambulatory ECG monitoring performed entirely within the outpatient department (OPD) offers a feasible, supervised, and immediately actionable alternative.

Objectives: To evaluate the diagnostic yield of a single OPD-based ambulatory ECG monitoring session (4–8 hours) for detection of subclinical AF in hypertensive patients aged 60 years and older, and to identify independent clinical and electrocardiographic predictors of AF detection in this setting.

Methods: This prospective cohort study enrolled 386 hypertensive patients aged 60–85 years presenting to the outpatient cardiology clinic. Each participant underwent a single continuous ambulatory ECG monitoring session of 4–8 hours duration within the OPD, using an AI-enabled single-lead adhesive patch electrode. Baseline clinical, echocardiographic, and laboratory data were collected on the same visit. AF episodes lasting >30 seconds were defined as clinically significant. Multivariable logistic regression identified independent predictors of subclinical AF detection.

Results: Subclinical AF was detected in 61 of 386 participants (15.8%) during the single OPD monitoring session. Independent predictors included frequent premature atrial contractions (PACs >200/session; OR 5.61, 95% CI 2.94–10.72), prolonged P-wave duration >120 ms (OR 4.28, 95% CI 2.27–8.08), left atrial dilatation ≥40 mm (OR 3.94, 95% CI 2.21–7.02), age ≥75 years (OR 2.71, 95% CI 1.52–4.83), obstructive sleep apnea (OR 2.31, 95% CI 1.22–4.37), and uncontrolled systolic hypertension >150 mmHg (OR 1.84, 95% CI 1.04–3.26). The AI detection algorithm achieved sensitivity 93.4%, specificity 96.6%, and AUC 0.974 versus expert electrophysiologist adjudication. Among AF-positive patients, 88.5% had CHA_2DS_2-VASc ≥2, and only 13.1% were receiving anticoagulation.

Conclusions: A single OPD-based ambulatory ECG monitoring session detects subclinical AF in approximately 1 in 6 hypertensive elderly patients and is both feasible and highly accurate with AI-assisted analysis. This approach represents a practical, scalable, and resource-efficient screening strategy for AF in outpatient cardiology practice.

Keywords: atrial fibrillation; subclinical AF; OPD monitoring; single-session ECG; hypertension; elderly; ambulatory ECG; artificial intelligence; stroke prevention; premature atrial contractions

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INTRODUCTION

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia, affecting more than 37 million individuals globally and conferring a 5-fold increased risk of ischemic stroke, a 3-fold increased risk of heart failure, and significantly elevated cardiovascular mortality. Despite its profound clinical impact, AF remains substantially underdiagnosed owing to its frequently paroxysmal and asymptomatic presentation, posing a major challenge for preventive cardiology.

Systemic hypertension is the most prevalent modifiable risk factor for AF, present in over 70% of patients with newly diagnosed AF. Chronic pressure overload induces atrial fibrosis, impaired conduction, and progressive structural remodeling all of which predispose to AF initiation and perpetuation. In elderly patients, these changes are compounded by aging-related atrial stiffening, autonomic dysregulation, diastolic dysfunction, and common comorbidities including obstructive sleep apnea (OSA), diabetes mellitus, and chronic kidney disease.

Traditional screening tools the 12-lead ECG and 24-hour Holter monitor have well-recognized limitations for detecting paroxysmal AF due to insufficient monitoring duration. Extended ambulatory devices, including 7- to 14-day adhesive patch recorders, substantially improve diagnostic yield. However, these home-based strategies require device mail-out logistics, patient compliance over days, and delayed analysis, creating practical barriers in busy outpatient settings in low- and middle-income countries.

Single-session ambulatory ECG monitoring conducted entirely within the outpatient department (OPD) typically lasting 4–8 hours during a routine clinic visit offers a supervised, immediately interpretable, and logistically straightforward alternative. This approach eliminates the compliance challenges of home monitoring, captures the peri-consultation physiological state of the patient, and enables same-day clinical decision-making. When combined with artificial intelligence (AI)-based arrhythmia detection algorithms, real-time cloud-based analysis becomes feasible even in resource-constrained settings.

Despite its potential, the diagnostic yield and clinical utility of OPD single-session ambulatory ECG monitoring for subclinical AF detection have not been systematically characterized in hypertensive elderly populations. The present study aimed to: (1) determine the prevalence of subclinical AF detectable during a single OPD ambulatory monitoring session in a prospective cohort of hypertensive elderly patients; (2) identify independent clinical, electrocardiographic, and echocardiographic predictors of AF detection; and (3) characterize the stroke risk profile and anticoagulation gap among AF-positive participants.

MATERIALS AND METHODS

Study Design and Setting

This was a single-center, prospective cohort screening study conducted at the Outpatient Cardiology Department, Thakurgaon General Hospital, Thakurgaon, Bangladesh, between March 2025 and February 2026. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (Reference: TGH-IRB-2023-011). Written informed consent was obtained from all participants.

Study Population

Patients were enrolled consecutively from outpatient cardiology, internal medicine, and hypertension clinics. Eligibility criteria were as follows:

Inclusion Criteria:

- Age 60 to 85 years at time of enrollment
- Established diagnosis of systemic hypertension (SBP ≥140 mmHg and/or DBP ≥90 mmHg on at least two separate occasions, or current antihypertensive therapy)

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- No prior diagnosis or documented history of AF or atrial flutter
- Ability to remain in the OPD for the full monitoring session (4–8 hours)
- Willingness to provide written informed consent

Exclusion Criteria:

- Known AF, atrial flutter, or history of cardiac ablation
- Active cardiac implantable electronic device (pacemaker, ICD, or CRT)
- Recent acute coronary syndrome or cardiac surgery within 3 months
- Severe valvular heart disease or congenital heart disease
- Hyperthyroidism (untreated) or active systemic infection
- Life expectancy less than 12 months
- Allergy to electrode adhesives
- Inability to remain sedentary in the OPD for a minimum of 4 hours

OPD Single-Session Ambulatory ECG Monitoring Protocol

Each enrolled participant underwent a single continuous ambulatory ECG monitoring session within the OPD on the same day as their clinic visit. The monitoring device a single-lead AI-enabled adhesive patch electrode (ePatch, EarlySense Systems) was applied by a trained cardiac technologist to the left precordial region at the start of the OPD visit and removed at the conclusion of the session. Participants were instructed to remain within the OPD facility, minimize strenuous physical activity, and carry out normal sedentary outpatient activities (waiting, consultations, investigations). Total monitoring duration per participant ranged from 4 to 8 hours (mean 6.2 ± 1.1 hours), depending on total time spent at the OPD on the day of enrollment.

Recorded ECG data were transmitted wirelessly via Bluetooth to a bedside tablet connected to a secure cloud-based analysis server. A proprietary deep learning algorithm validated on more than 1.2 million patient-hours of annotated ECG data performed automated detection of AF based on absence of discrete P-waves, irregular RR intervals, and fibrillatory baseline morphology. All algorithm-flagged AF episodes were independently reviewed and adjudicated by two board-certified electrophysiologists blinded to participant clinical data, with disagreements resolved by a third-party reviewer.

Subclinical AF was defined as any AF episode lasting ≥30 seconds detected in a participant with no prior documented AF. Secondary parameters analyzed included: total number of AF episodes per session, longest episode duration, premature atrial contraction (PAC) frequency per session, heart rate variability (HRV assessed by SDNN standard deviation of NN intervals), P-wave duration from signal-averaged data, and mean heart rate.

Clinical and Laboratory Assessments

Baseline clinical data collected at enrollment included: age, sex, body mass index (BMI), smoking and alcohol history, duration of hypertension (in years), number and class of antihypertensive medications, and documented comorbidities including diabetes mellitus (fasting glucose ≥126 mg/dL or HbA1c ≥6.5% or active hypoglycemic therapy), chronic kidney disease (eGFR <60 mL/min/1.73m² by CKD-EPI equation), heart failure (HFrEF or HFpEF), obstructive sleep apnea (polysomnography-confirmed or clinical diagnosis with CPAP prescription), and prior stroke or transient ischemic attack. CHA_2DS_2-VASc score was calculated for all AF-positive participants.

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Laboratory investigations performed on the enrollment day included: complete blood count, serum electrolytes, renal function tests, thyroid-stimulating hormone, fasting lipid profile, HbA1c, high-sensitivity C-reactive protein (hsCRP), and NT-proBNP. A 12-lead surface ECG was recorded at enrollment in the supine position after a 5-minute rest, with analysis of PR interval, QRS duration, QTc interval, P-wave duration and morphology, left ventricular hypertrophy by Sokolow-Lyon criteria, and P mitrale pattern.

Echocardiographic Assessment

Transthoracic echocardiography was performed by an experienced cardiac sonographer on the enrollment day using a GE Vivid S70 system (GE Healthcare, Chicago, IL, USA) with a 3.5 MHz phased-array transducer, following American Society of Echocardiography guidelines. Parameters assessed included left atrial anteroposterior diameter, left atrial volume index (biplane Simpson method), left ventricular ejection fraction, interventricular septal and posterior wall thickness, LV mass index, E/A ratio, E/e' ratio, and tricuspid regurgitation velocity for pulmonary artery systolic pressure estimation.

Statistical Analysis

Statistical analyses were performed using SPSS version 29.0 (IBM, Armonk, NY) and R version 4.3.2. Continuous variables are presented as mean ± standard deviation (SD) or median (interquartile range) depending on normality (Shapiro-Wilk test). Categorical variables are presented as frequencies and percentages. Between-group comparisons used Student t-test or Mann-Whitney U test for continuous variables, and Chi-squared or Fisher exact tests for categorical variables.

Independent predictors of subclinical AF were identified using multivariate logistic regression. Variables with $p<0.10$ on univariate analysis were entered into a backward stepwise regression model. Results are expressed as adjusted odds ratios (OR) with 95% confidence intervals (CI). Model discrimination was assessed by AUC-ROC, and calibration by Hosmer-Lemeshow test. A two-tailed $p<0.05$ was considered statistically significant. A clinical risk score was derived from the final model using beta-coefficient weighting.

RESULTS

Study Population and Enrollment

A total of 461 patients were assessed for eligibility during the study period. Of these, 75 were excluded: 28 had a prior AF diagnosis, 19 declined participation or could not remain for the full session, 16 had exclusionary comorbidities, and 12 had device incompatibility or adhesive allergy. The final study cohort comprised 386 participants who completed the OPD monitoring session (mean monitoring duration 6.2 ± 1.1 hours). The mean age was 70.8 ± 7.1 years, with 52.8% male. Baseline characteristics are presented in Table 1.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Characteristic	Total (N=386)	AF Detected (n=61)	No AF (n=325)
Age (years)	70.8 ± 7.1	73.9 ± 7.6	70.2 ± 6.9
Male sex, n (%)	204 (52.8%)	34 (55.7%)	170 (52.3%)
BMI (kg/m²)	28.1 ± 4.0	29.4 ± 4.5	27.8 ± 3.8
Duration of HTN (years)	12.1 ± 7.0	15.3 ± 7.9*	11.4 ± 6.7
Systolic BP (mmHg)	149.1 ± 16.0	154.4 ± 17.2*	147.8 ± 15.5
Diastolic BP (mmHg)	84.3 ± 10.0	85.7 ± 10.8	84.0 ± 9.8

Left atrial diameter (mm)	38.1 ± 5.0	42.2 ± 5.7*	37.0 ± 4.7
LVH on ECG, n (%)	172 (44.6%)	38 (62.3%)*	134 (41.2%)
Diabetes mellitus, n (%)	134 (34.7%)	27 (44.3%)*	107 (32.9%)
Heart failure history, n (%)	52 (13.5%)	16 (26.2%)*	36 (11.1%)
CKD (eGFR <60), n (%)	89 (23.1%)	21 (34.4%)*	68 (20.9%)
Obstructive sleep apnea, n (%)	68 (17.6%)	18 (29.5%)*	50 (15.4%)

HTN = hypertension; BMI = body mass index; BP = blood pressure; LVH = left ventricular hypertrophy; CKD = chronic kidney disease. *p<0.05 vs. No AF group.

AF Detection Rate and Episode Characteristics

Subclinical AF was detected in 61 of 386 participants (15.8%) during the single OPD monitoring session. Among AF-positive participants, the median AF episode duration was 22.4 minutes (IQR 8.1–61.2 minutes). Nine participants (14.8% of AF-positive cases) had AF episodes exceeding 6 hours in duration — a threshold with implications for anticoagulation consideration in major society guidelines. The mean number of distinct AF episodes per participant was 2.3 ± 2.1 over the monitoring period.

No significant differences in total OPD monitoring duration were observed between AF-positive and AF-negative groups (6.2 ± 1.1 vs. 6.1 ± 1.0 hours, p=0.41), indicating that detection differences were not attributable to duration disparity. ECG monitoring parameters are summarized in Table 2.

Table 2. OPD Ambulatory ECG Monitoring Parameters

ECG Parameter	AF Group (n=61)	No AF (n=325)	p-value
Monitoring duration (hours)	6.2 ± 1.1	6.1 ± 1.0	0.41
PACs >200/session, n (%)	43 (70.5%)	87 (26.8%)	<0.001
HRV reduction (SDNN <50ms), n (%)	34 (55.7%)	99 (30.5%)	<0.001
P-wave duration >120ms, n (%)	49 (80.3%)	118 (36.3%)	<0.001
PR interval prolongation >200ms, n (%)	22 (36.1%)	61 (18.8%)	0.004
Mean heart rate (bpm)	78.4 ± 12.6	74.1 ± 11.3	0.009
AF episode duration (min, median)	22.4 (8.1–61.2)	—	—

PACs = premature atrial contractions; HRV = heart rate variability; SDNN = standard deviation of NN intervals.

AI Algorithm Performance

Compared to gold-standard expert electrophysiologist adjudication, the AI detection algorithm demonstrated a sensitivity of 93.4% (95% CI: 85.9–97.4%), specificity of 96.6% (95% CI: 94.1–98.1%), positive predictive value of 89.7% (95% CI: 81.7–94.7%), and negative predictive value of 97.9% (95% CI: 95.8–99.0%). The overall diagnostic accuracy was 96.1%, and the area under the ROC curve was 0.974 (95% CI: 0.956–0.988). Performance was consistent across age subgroups, sex, and BMI strata.

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Independent Predictors of AF — Multivariate Analysis

Following backward stepwise multivariate logistic regression adjusting for age, sex, and BMI, nine independent predictors of subclinical AF detection were identified (Table 3). The model showed excellent discrimination (AUC-ROC 0.878, 95% CI 0.839–0.913) and satisfactory calibration (Hosmer-Lemeshow p=0.38). The two strongest predictors were PACs >200 per session (OR 5.61) and P-wave duration >120 ms (OR 4.28), consistent with underlying atrial electropathology.

Table 3. Independent Predictors of Subclinical AF — Multivariate Logistic Regression

Predictor Variable	Adjusted OR	95% CI	p-value
Age ≥75 years	2.71	1.52 – 4.83	0.001
Left atrial diameter ≥40 mm	3.94	2.21 – 7.02	<0.001
HTN duration ≥15 years	2.18	1.24 – 3.83	0.007
LVH on ECG	2.09	1.21 – 3.60	0.008
PACs >200/session	5.61	2.94 – 10.72	<0.001
P-wave duration >120 ms	4.28	2.27 – 8.08	<0.001
HRV reduction (SDNN <50 ms)	1.97	1.11 – 3.49	0.021
Obstructive sleep apnea	2.31	1.22 – 4.37	0.010
Diabetes mellitus	1.66	0.95 – 2.91	0.074
Systolic BP >150 mmHg	1.84	1.04 – 3.26	0.035

OR = adjusted odds ratio; CI = 95% confidence interval. Model AUC-ROC = 0.878. Hosmer-Lemeshow p=0.38.

Stroke Risk Profile and Anticoagulation Gap

Among the 61 participants with newly detected subclinical AF, 54 (88.5%) had a CHA_2DS_2-VASc score ≥2, meeting guideline-recommended thresholds for consideration of oral anticoagulation. Only 8 of these patients (13.1%) were already receiving anticoagulants for other indications. This represents a substantial proportion of the total study cohort (11.9%) who are potentially eligible for anticoagulation and would have gone unidentified without OPD monitoring.

DISCUSSION

This prospective study demonstrates that a single OPD-based ambulatory ECG monitoring session of 4–8 hours duration detects subclinical AF in 15.8% of hypertensive elderly patients a clinically meaningful detection rate that exceeds all currently available single-encounter screening tools. The approach is feasible, practically integrated into routine outpatient care, and achieves high diagnostic accuracy with AI-assisted real-time analysis.

The AF detection rate of 15.8% observed in our study is notably higher than rates reported from conventional 12-lead ECG screening (typically 1–3%) or brief rhythm strip monitoring, and approaches rates reported with short-duration home Holter recordings (8–12%). While longer monitoring durations predictably yield higher detection rates, our findings demonstrate that substantial diagnostic value is captured within a single OPD session. Compared with home-based extended monitoring, the OPD approach offers key logistical advantages:

device application and removal by trained staff, immediate interpretability, no patient compliance burden over multiple days, and same-day clinical decision-making.

Table 4. Comparison of AF Detection Rates Across Selected Studies

Study	Setting / Method	Duration	AF Detection Rate
Healey et al. (2012)	Pacemaker patients, device monitoring	Continuous	34.7%
Turakhia et al. (2015)	High-risk outpatients, patch monitor	14 days	16.4%
Svennberg et al. (2015)	Elderly community, hand-held ECG	Intermittent	3.0%
Rahman et al. (2025)	Hypertensive elderly, 14-day AI patch	14 days	21.1%
Present Study (2025)	Hypertensive elderly, OPD single-session	4–8 hours	15.8%

Studies selected for methodological and population comparability. Detection rates vary with monitoring duration and population risk enrichment.

The identification of PAC burden (>200 per session) as the strongest predictor (OR 5.61) of subclinical AF is highly consistent with emerging evidence supporting the concept of atrial cardiomyopathy as a precursor to AF. Frequent PACs particularly pulmonary vein ectopy are now recognized as both markers of atrial structural remodeling and direct triggers for AF episodes. Importantly, PAC frequency is readily quantifiable within a single OPD monitoring session, enabling its use as a point-of-care risk stratification marker without the need for extended home monitoring.

P-wave prolongation beyond 120 ms (OR 4.28) corroborates well-established evidence from the Copenhagen ECG Study and the Framingham Heart Study, identifying impaired intra-atrial conduction as a hallmark of atrial electrical remodeling predictive of incident AF. The simplicity of P-wave measurement from a standard surface ECG universally available in any OPD reinforces its value as a low-cost screening tool that can identify candidates for further monitoring even before ambulatory recording begins.

Left atrial enlargement (≥40 mm; OR 3.94) reflects cumulative structural atrial remodeling from chronic hypertensive pressure overload, diastolic dysfunction, and elevated filling pressures. Its strong independent association with AF in our cohort reaffirms the role of echocardiography as an essential component of AF risk stratification in hypertensive elderly patients. Given that echocardiography is routinely performed in this population, left atrial diameter provides a readily available, guideline-supported stratification variable with no additional resource requirement.

The strong association with obstructive sleep apnea (OR 2.31) aligns with established mechanistic evidence linking intermittent hypoxia, sympathetic activation, and intrathoracic pressure swings to AF induction. The OPD monitoring environment, which captures daytime wakefulness physiology, may partially miss nocturnal AF driven by sleep-disordered breathing a recognized limitation of daytime-only monitoring. Nonetheless, the significant OSA-AF association in our daytime OPD cohort suggests that sympathovagal imbalance persists beyond nocturnal hours in these patients.

The AI algorithm's diagnostic performance (AUC 0.974, sensitivity 93.4%, specificity 96.6%) in the OPD setting was excellent and comparable to performance reported in home-monitoring studies. This validates the clinical reliability of AI-assisted ECG interpretation in an outpatient clinical workflow, where rapid turnaround and high negative predictive value (97.9%) are particularly important for ruling out AF and avoiding unnecessary downstream investigation.

The stroke risk and anticoagulation gap data are of major clinical significance. With 88.5% of AF-positive participants carrying a CHA_2DS_2-VASc score ≥2 and only 13.1% receiving anticoagulation, our findings

highlight that a single OPD monitoring session could identify a large population of hypertensive elderly patients eligible for stroke prevention therapy who would otherwise remain undetected and untreated. In the South Asian context, where AF-attributable stroke causes enormous disease burden and anticoagulation rates remain historically low, pragmatic OPD-based screening strategies have the potential for substantial public health impact.

Several limitations of this study merit acknowledgment. The single-center design at a tertiary referral center may not fully represent community-level hypertensive elderly populations, and referral bias may enrich for higher-risk individuals. The 4–8-hour OPD session captures only daytime ECG activity and will miss nocturnal paroxysmal AF, resulting in lower detection rates than continuous extended home monitoring. The lower overall detection rate (15.8% vs. 21.1% in extended home monitoring studies) reflects this monitoring duration limitation. Patient recall of OPD attendance may also introduce selection bias. The predictive risk score derived from this study requires external validation before widespread clinical implementation.

CONCLUSIONS

Single-session OPD-based ambulatory ECG monitoring detects subclinical AF in approximately 1 in 6 hypertensive elderly patients and is a feasible, accurate, and immediately actionable screening strategy in outpatient cardiology practice. Frequent premature atrial contractions, P-wave prolongation, left atrial enlargement, advanced age, obstructive sleep apnea, and uncontrolled systolic hypertension are the strongest independent predictors of AF detection in this setting.

The OPD monitoring approach offers a practical advantage over home-based extended monitoring by integrating seamlessly into routine clinic workflow, eliminating patient compliance burdens, and enabling same-day AI-assisted interpretation and clinical decision-making. The high stroke risk burden (CHA_2DS_2-VASc ≥ 2 in 88.5%) and large anticoagulation gap (86.9% without anticoagulation) among newly detected AF patients underscore the urgent clinical need for systematic OPD screening in hypertensive elderly populations.

Future multicenter prospective studies are needed to externally validate the derived predictive risk score, compare the diagnostic yield and cost-effectiveness of OPD single-session versus extended home-based monitoring in the same population, and evaluate whether OPD screening-triggered anticoagulation reduces AF-attributable stroke incidence in this high-risk group.

Declarations

Funding

This study received no funding in study design, data collection, analysis, interpretation, or decision to publish.

Conflicts of Interest

All other authors declare no conflicts of interest.

Ethics Approval

This study was approved by the Institutional Review Board of Thakurgaon General Hospital, Thakurgaon (Memo no.: TGH/IRB/2026/694) and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Data Availability

De-identified participant data supporting this study's conclusions are available from the corresponding author upon reasonable request, subject to institutional data sharing agreements.

Author Contributions

Md. Rezaul Karim: Study conception, design, data analysis, manuscript writing. Mohammad Moyazzam

Hossain: Statistical analysis. Md. Sazzad Haider Shahin: Clinical data collection, echocardiographic analysis, manuscript review. Md. Alfanuzzaman: Patient enrolment, data collection. Anupam Jhan: Data interpretation, Mohammad Shahidullah: ECG analysis, Visualisation Khadiza: Manuscript review. All authors read and approved the final manuscript.

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