

Journal Homepage: www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/24331
DOI URL: <http://dx.doi.org/10.21474/IJAR01/24331>



RESEARCH ARTICLE

ROLE OF AMBULATORY HOLTER ELECTROCARDIOGRAPHIC MONITORING IN DETECTING ATRIAL FIBRILLATION IN PATIENTS WITH ISCHEMIC STROKE

Asmaa Kriouile, Ibtissam Fellat and Mohammed Cherti

1. Department of Cardiology B, Ibn Sina University Hospital, Rabat, Morocco; Faculty of Medicine and Pharmacy of Rabat, Mohammed V University, Rabat, Morocco.

Manuscript Info

Manuscript History

Received: 08 August 2026

Final Accepted: 10 September 2026

Published: October 2026

Key words:-

Atrial fibrillation; Ischemic stroke;
Holter electrocardiography; Ambulatory
cardiac monitoring; Hypertension;
Cardioembolic stroke; Secondary stroke
prevention; Oral anticoagulation

Abstract

Background: Atrial fibrillation (AF) accounts for 20–30% of ischemic strokes and is often paroxysmal and clinically silent, which limits its diagnosis on standard electrocardiography. Ambulatory Holter electrocardiographic (ECG) monitoring is the most accessible screening tool after ischemic stroke. This study assessed the diagnostic yield of short-duration ambulatory Holter monitoring for AF detection after ischemic stroke and identified the factors associated with detection.

Methods: This retrospective, descriptive and analytical, single-center study was conducted in the Department of Cardiology, Ibn Sina University Hospital, Rabat, Morocco, from January 2025 to April 2026. Patients with imaging-confirmed ischemic stroke, no previously known AF, and a 24–72-hour ambulatory Holter ECG were included. Of 1,431 Holter recordings performed during the study period, 60 concerned stroke patients; three were excluded for insufficient data, leaving 57 patients. Age, sex, hypertension, and type 2 diabetes were recorded. Holter results were classified as sustained AF (≥ 30 seconds), non-sustained AF (< 30 seconds), pure atrial hyperexcitability, isolated ventricular hyperexcitability, or normal. Group comparisons used the chi-square test (Yates-corrected) or Fisher's exact test for categorical variables, and the Mann-Whitney test for continuous variables; $p < 0.05$ was considered significant.

Results: Mean age was 67.0 ± 11.6 years, 50.9% were male, 42.1% had hypertension, and 24.6% had type 2 diabetes. AF was detected in 13 patients (22.8%): sustained in 2 (3.5%) and non-sustained in 11 (19.3%). Pure atrial hyperexcitability was found in 14 patients (24.6%), giving an overall atrial abnormality in 27 patients (47.4%).

"© 2026 by the Author(s). Published by IJAR under CC BY 4.0. Unrestricted use allowed with credit to the author."

Isolated ventricular hyperexcitability was present in 8 patients (14.0%), and the Holter was normal in 22 (38.6%). Atrial abnormality was significantly associated with hypertension (74.1% vs 13.3%, $p < 0.001$) and older age (70.3 ± 12.0 vs 64.0 ± 10.5 years, $p = 0.044$), but not with sex ($p = 0.686$) or diabetes ($p = 0.077$).

Conclusion: Short-duration ambulatory Holter ECG detected AF in nearly one in four patients after ischemic stroke, although sustained AF remained uncommon. Hypertension and older age were the main factors associated with

Corresponding Author:- Asmaa Kriouile

Address:-Department of Cardiology B, Ibn Sina University Hospital, Rabat, Morocco; Faculty of Medicine and Pharmacy of Rabat, Mohammed V University, Rabat, Morocco.

atrial abnormality detection, supporting a stepwise, risk-based approach to rhythm monitoring, with prolonged monitoring considered in this subgroup, a strategy that warrants confirmation in prospective studies.

Introduction:-

Ischemic stroke is a leading cause of death and disability worldwide, with an estimated global incidence of 12.2 million new cases per year and a rising burden linked to population ageing ^[1]. Atrial fibrillation (AF) is one of the most important and most preventable causes of ischemic stroke, accounting for 20–30% of cases and multiplying stroke risk approximately five-fold independently of other cardiovascular risk factors ^[2]. Strokes related to AF tend to be more severe, with higher short- and long-term mortality than strokes of other etiologies ^[4]. The main diagnostic challenge is that AF is frequently paroxysmal and asymptomatic: 50–87% of episodes are initially clinically silent, and a single admission electrocardiogram captures only an instantaneous rhythm, with limited sensitivity for intermittent arrhythmia ^[9]. This diagnostic gap led to the concept of embolic stroke of undetermined source (ESUS), which represents around 17% of ischemic strokes and is the population in whom occult AF screening is most relevant ^[12].

Ambulatory Holter ECG monitoring is the most accessible screening tool for AF after ischemic stroke. Its diagnostic yield increases with recording duration: a 7-day Holter can detect paroxysmal AF in around 12.5% of patients in sinus rhythm at admission ^[14]. For high-risk patients, insertable cardiac monitors provide higher detection rates over prolonged follow-up. The 2024 ESC guidelines recommend prolonged ECG monitoring after unexplained ischemic stroke (Class I) ^[9], and detection of AF directly changes management by allowing early initiation of oral anticoagulation for secondary prevention. This study aimed to evaluate the diagnostic yield of short-duration (24–72-hour) ambulatory Holter ECG monitoring for AF detection in patients with ischemic stroke at a Moroccan university hospital, and to identify clinical factors associated with detection.

Materials and Methods:-

Study design and setting:-

This was a retrospective, descriptive and analytical, single-center study conducted in the Department of Cardiology, Ibn Sina University Hospital, Rabat, Morocco, over a 16-month period from January 1, 2025, to April 30, 2026. Patients were referred to the Cardiology Department, mainly from the Neurology Department, for ambulatory Holter ECG monitoring as part of the etiological work-up of a recently documented ischemic stroke. During the study period, 1,431 Holter ECG recordings were performed in the department. Of these, 60 concerned patients with ischemic stroke (4.2% of all recordings); three patients were excluded for insufficient data (incomplete data collection form), leaving 57 patients for analysis.

Population:-

Inclusion criteria were: age ≥ 18 years; imaging-confirmed ischemic stroke (computed tomography and/or magnetic resonance imaging); no previously known AF (no documented history, no pre-existing anticoagulation for this indication); ambulatory Holter ECG performed after the stroke as part of the etiological work-up; and a complete data collection form. Exclusion criteria were: known AF prior to the stroke; hemorrhagic or other non-ischemic stroke; incomplete data; and refusal or premature discontinuation of Holter monitoring.

Data collection and definitions:-

Age, sex, hypertension, and type 2 diabetes were collected from medical records. Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic ≥ 90 mmHg on at least two occasions, or antihypertensive treatment ^[21]. Diabetes was defined as fasting glucose ≥ 1.26 g/L on two occasions, HbA1c $\geq 6.5\%$, or antidiabetic treatment ^[22]. Holter ECG results were classified, on a mutually exclusive basis according to the most severe abnormality, as: sustained AF (≥ 30 seconds); non-sustained AF (< 30 seconds); pure atrial hyperexcitability (≥ 500 atrial premature beats/24h and/or atrial runs ≥ 3 consecutive complexes, without any AF episode); isolated ventricular hyperexcitability (≥ 500 ventricular premature beats/24h and/or ventricular couplets/runs, without atrial abnormality), reported descriptively only; or normal Holter. The primary outcome was detection of an overall atrial abnormality, defined as sustained AF, non-sustained AF, or pure atrial hyperexcitability. Secondary outcomes were AF of any form (sustained or non-sustained), sustained AF alone, and isolated ventricular hyperexcitability.

Statistical analysis:-

Data were analyzed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median [interquartile range] according to distribution (Shapiro-Wilk test), and compared

using the Student t test or Mann-Whitney test. Categorical variables were expressed as counts and percentages and compared using the chi-square test with Yates continuity correction, or Fisher's exact test when expected cell counts were below 5. The population was stratified into an "atrial abnormality+" group (n = 27) and an "atrial abnormality–" group (n = 30, combining normal Holters and isolated ventricular hyperexcitability). Given the limited sample size, no multivariable analysis was performed; associations are therefore univariate and unadjusted for potential confounders. A p value < 0.05 was considered statistically significant.

Ethical considerations:-

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki [27]. Given its retrospective, observational design and the use of pre-existing, anonymized medical records, no direct patient intervention was performed and formal prior ethics committee review was not required under institutional policy. The study was authorized by the administration of the Department of Cardiology B, Ibn Sina University Hospital, Rabat. Each patient was identified by an anonymous code; no nominative data were used in the analysis or in the presentation of results. Informed consent was not obtained given the retrospective, anonymized nature of the data collection.

Results:-

General population characteristics:-

Fifty-seven patients were included: 29 men (50.9%) and 28 women (49.1%), a male-to-female ratio of 1.04. Mean age was 67.0 ± 11.6 years (range 44–97; median 68.0 [interquartile range 58–76]), and 35 patients (61.4%) were aged 65 years or older. Hypertension was present in 24 patients (42.1%) and type 2 diabetes in 14 (24.6%).

Holter ECG results:-

Overall, 27 patients (47.4%) had at least one atrial abnormality (primary outcome). Sustained AF was found in 2 patients (3.5%), non-sustained AF in 11 (19.3%, all with associated atrial hyperexcitability), and pure atrial hyperexcitability in 14 (24.6%). Isolated ventricular hyperexcitability was found in 8 patients (14.0%), and the Holter was normal in 22 (38.6%). AF of any form (sustained or non-sustained) was detected in 13 patients (22.8%). Results are summarized in Table 1.

Table 1. Distribution of Holter ECG results (n = 57)

Holter ECG result	n	%	Analytic status
Sustained AF (≥ 30 s)	2	3.5%	Secondary outcome
Non-sustained AF (< 30 s)	11	19.3%	Secondary outcome
Pure atrial hyperexcitability	14	24.6%	Secondary outcome
Overall atrial abnormality (primary outcome)	27	47.4%	Primary outcome
Isolated ventricular hyperexcitability	8	14.0%	Descriptive only
Normal Holter	22	38.6%	Control group
Total	57	100%	—

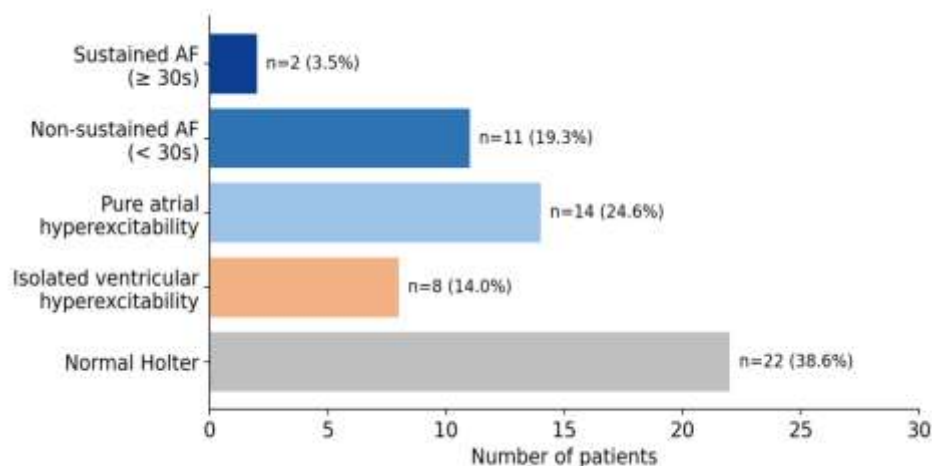


Figure 1. Distribution of Holter ECG results (n = 57).

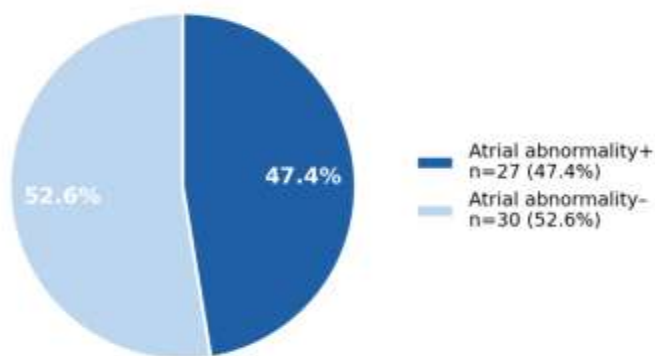


Figure 2. Proportion of patients with an atrial abnormality on Holter ECG (n = 57).

Factors associated with atrial abnormality detection:-

Patients with an atrial abnormality were significantly older than those without (70.3 ± 12.0 vs 64.0 ± 10.5 years, $p = 0.044$). Sex distribution did not differ significantly between groups (55.6% vs 46.7% male, $p = 0.686$). Hypertension was significantly more frequent in the atrial abnormality+ group (74.1% vs 13.3%, $p < 0.001$), making it the factor most strongly associated with atrial abnormality in this series. Type 2 diabetes was more frequent in the atrial abnormality+ group (37.0% vs 13.3%) but did not reach statistical significance ($p = 0.077$), possibly owing to the limited sample size. Results are summarized in Table 2.

Table 2. Comparative analysis between the atrial abnormality+ and atrial abnormality- groups

Variable	Atrial abnormality + (n=27)	Atrial abnormality – (n=30)	p
Mean age $\pm$ SD (years)	70.3 ± 12.0	64.0 ± 10.5	0.044*
Age $\geq$ 65 years	19 (70.4%)	16 (53.3%)	—
Male sex	15 (55.6%)	14 (46.7%)	0.686
Hypertension	20 (74.1%)	4 (13.3%)	<0.001**
Type 2 diabetes	10 (37.0%)	4 (13.3%)	0.077

*Mann-Whitney test. **Chi-square test with Yates continuity correction.

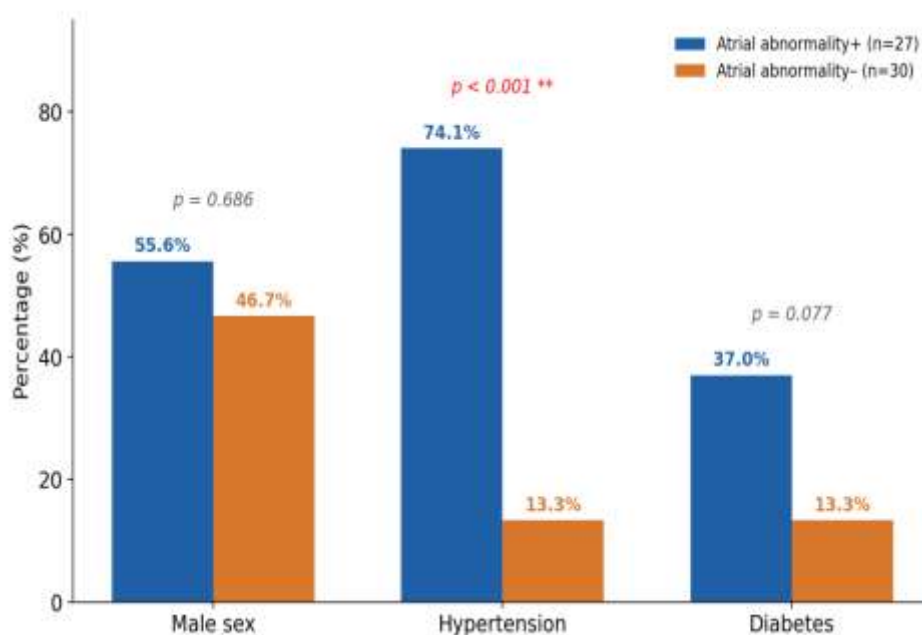


Figure 3. Comparison of risk factors between the atrial abnormality+ and atrial abnormality- groups.

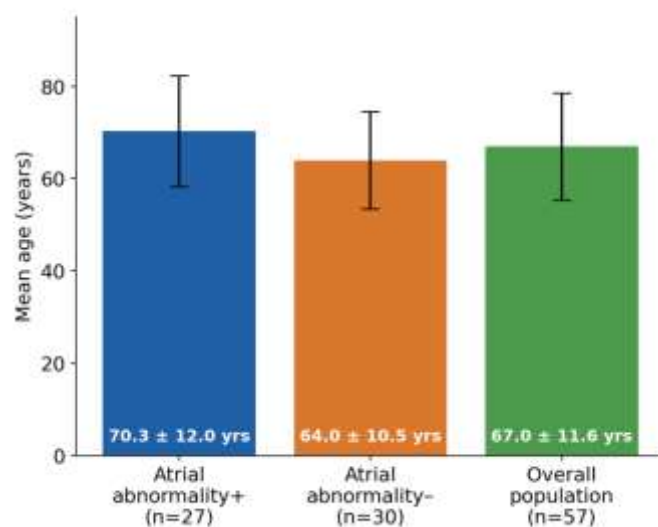


Figure 4. Comparison of mean age between the two groups.

Discussion:-

Population characteristics:-

Our population had a near-equal sex distribution (50.9% male), contrasting with the male predominance usually reported in the literature, including the Brazzaville series (61.4% male) [26] and major international trials such as CRYSTAL-AF and Find-AF [14,17]. Mean age (67.0 ± 11.6 years) was consistent with international series (65–72 years) [1], while being higher than the Brazzaville cohort (60.2 ± 12.1 years) [26], possibly reflecting an earlier onset of stroke in sub-Saharan African populations related to poorly controlled hypertension. Hypertension prevalence (42.1%) was lower than reported in the MonDAFIS trial (73%) [16] and the Brazzaville series (80.1%) [26], which may reflect selection bias inherent to a retrospective design and the specific referral pattern of patients addressed for Holter monitoring. Diabetes prevalence (24.6%) was consistent with Moroccan epidemiological data.

AF detection rate in comparison with the literature:-

AF of any form was detected in 22.8% of patients, a figure of similar order of magnitude to the meta-analysis by Sposato et al., which estimated AF detection at approximately 24% with intensive cardiac monitoring after stroke or transient ischemic attack [5]. However, this comparison should be interpreted cautiously: monitoring durations and populations differ across studies, and our 22.8% figure includes non-sustained episodes (< 30 seconds). For comparison with the literature, our sustained AF rate (3.5%) is the more directly comparable figure, and is consistent with the 1–5% range reported for standard 24–72-hour Holter monitoring [15]. The Brazzaville series, using 24-hour Holter monitoring only, found a lower paroxysmal AF rate of 2.6% [26], illustrating the direct relationship between monitoring duration and diagnostic yield, a principle first established by Stahrenberg et al. in the Find-AF study, where extending monitoring to 7 days detected AF in 12.5% of patients [14]. Beyond AF itself, pure atrial hyperexcitability (24.6%) is noteworthy: frequent atrial premature beats and runs have been shown to be independent markers of subsequent AF and stroke risk (hazard ratios of 2.10 and 2.72, respectively) [19], suggesting that patients in this subgroup may benefit from closer follow-up, including consideration of prolonged monitoring.

Factors associated with atrial abnormality:-

Age and hypertension were the two factors significantly associated with atrial abnormality detection in our series, consistent with the wider literature. In the Brazzaville cohort, age was the only independent predictor of paroxysmal AF on multivariable analysis ($p = 0.0134$) [26]. Hypertension-driven atrial remodeling, through interstitial fibrosis, myocyte hypertrophy, and connexin alteration, provides a plausible mechanistic basis for this association [20], and the ARIC study identified hypertension as the leading population-attributable risk factor for AF [23]. Sex was not associated with detection ($p = 0.686$), consistent with the removal of female sex from the CHA2DS2-VA score in the 2024 ESC guidelines [9,10]. Diabetes showed a non-significant trend ($p = 0.077$), most likely reflecting limited statistical power rather than absence of association [24].

Limitations:-

This study has several limitations. Its retrospective design exposes it to information and selection bias and depends on the completeness of medical records. The sample size ($n = 57$) limits statistical power and precluded multivariable analysis. Holter duration varied between 24 and 72 hours without systematic standardization, and this variable directly affects diagnostic yield^[14]. Echocardiographic parameters (left atrial size, ejection fraction) and a standardized stroke etiological classification (TOAST/ESUS) were not collected, limiting the identification of independent predictors. Finally, the single-center design limits the generalizability of these findings.

Conclusion:-

In this retrospective single-center study, short-duration ambulatory Holter ECG monitoring detected atrial fibrillation in nearly one in four patients with ischemic stroke, although sustained AF remained uncommon (3.5%). Hypertension and older age were the main factors associated with the detection of an atrial abnormality. These findings support a risk-based approach to post-stroke rhythm monitoring, with consideration of prolonged monitoring in older, hypertensive patients, a hypothesis that warrants confirmation through prospective, multicenter studies with standardized monitoring protocols.

Conflicts of interest:-

The authors declare no conflict of interest.

Funding:-

This research received no specific grant from any funding agency.

References:-

1. GBD 2019 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Neurol.* 2021;20(10):795–820.
2. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham Study. *Stroke.* 1991;22(8):983–988.
3. Linz D, Gawalko M, Betz K, et al. Atrial fibrillation: epidemiology, screening and digital health. *Lancet Reg Health Eur.* 2024;37:100786.
4. Marini C, De Santis F, Sacco S, et al. Contribution of atrial fibrillation to incidence and outcome of ischemic stroke. *Stroke.* 2005;36(6):1115–1119.
5. Sposato LA, Cipriano LE, Saposnik G, et al. Diagnosis of atrial fibrillation after stroke and transient ischaemic attack: a systematic review and meta-analysis. *Lancet Neurol.* 2015;14(4):377–387.
6. Haissaguerre M, Jais P, Shah DC, et al. Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. *N Engl J Med.* 1998;339(10):659–666.
7. Nattel S, Dobrev D. Electrophysiological and molecular mechanisms of paroxysmal atrial fibrillation. *Nat Rev Cardiol.* 2016;13(10):575–590.
8. Goette A, Kalman JM, Aguinaga L, et al. EHRA/HRS/APHRS/SOLAECE expert consensus on atrial cardiomyopathies. *Europace.* 2016;18(10):1455–1490.
9. Van Gelder IC, Rienstra M, Bunting KV, et al. 2024 ESC Guidelines for the management of atrial fibrillation. *Eur Heart J.* 2024;45(36):3314–3414.
10. Mei DA, Romiti GF, Corica B, et al. CHA2DS2-VA instead of CHA2DS2-VASc for stroke risk stratification in patients with atrial fibrillation. *Eur Heart J Cardiovasc Pharmacother.* 2025;11(1):7–13.
11. Adams HP Jr, Bendixen BH, Kappelle LJ, et al. Classification of subtype of acute ischemic stroke (TOAST). *Stroke.* 1993;24(1):35–41.
12. Hart RG, Diener HC, Coutts SB, et al. Embolic strokes of undetermined source: the case for a new clinical construct. *Lancet Neurol.* 2014;13(4):429–438.
13. Hart RG, Catanese L, Perera KS, et al. Embolic stroke of undetermined source: a systematic review and clinical update. *Stroke.* 2017;48(4):867–872.
14. Stahrenberg R, Weber-Krüger M, Seegers J, et al. Enhanced detection of paroxysmal atrial fibrillation by early and prolonged continuous Holter monitoring in patients with cerebral ischemia. *Stroke.* 2010;41(12):2884–2888.
15. Bienkowski WJ, Bienkowski M, Kusy B, et al. The application of Holter monitoring in the diagnosis of atrial fibrillation and its significance in the context of ischemic strokes. *Wiad Lek.* 2025;78(6):1150–1159.
16. Haeusler KG, Schaefer JH, Köhrmann M, et al. Systematic monitoring for detection of atrial fibrillation in patients with acute ischaemic stroke (MonDAFIS). *Lancet Neurol.* 2021;20(6):426–436.

17. Sanna T, Diener HC, Passman RS, et al. Cryptogenic stroke and underlying atrial fibrillation (CRYSTAL AF). *N Engl J Med*. 2014;370(26):2478–2486.
18. Krisai P, Aeschbacher S, Blum S, et al. Global results of implantable loop recorder for detection of atrial fibrillation after stroke: Reveal LINQ Registry. *J Am Heart Assoc*. 2024;13(22):e036081.
19. Binici Z, Intzilakis T, Nielsen OW, et al. Excessive supraventricular ectopic activity and increased risk of atrial fibrillation and stroke. *Circulation*. 2010;121(17):1904–1911.
20. Kamel H, Okin PM, Elkind MS, Iadecola C. Atrial fibrillation and mechanisms of stroke: time for a new model. *Stroke*. 2016;47(3):895–900.
21. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J*. 2018;39(33):3021–3104.
22. American Diabetes Association Professional Practice Committee. Diagnosis and classification of diabetes: standards of care in diabetes—2024. *Diabetes Care*. 2024;47(Suppl 1):S20–S42.
23. Huxley RR, Lopez FL, Folsom AR, et al. Absolute and attributable risks of atrial fibrillation in relation to optimal and borderline risk factors: the ARIC study. *Circulation*. 2011;123(14):1501–1508.
24. Aksnes TA, Schmieder RE, Kjeldsen SE, et al. Impact of new-onset diabetes mellitus on development of atrial fibrillation and heart failure in high-risk hypertension (from the VALUE Trial). *Am J Cardiol*. 2008;101(5):634–638.
25. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the ASE and the EACVI. *J Am Soc Echocardiogr*. 2015;28(1):1–39.e14.
26. Méo Ikama S, Makani J, Mpandzou G, et al. Contribution of Holter ECG in the etiologic diagnosis of ischemic stroke in Brazzaville, Congo. *Pan Afr Med J*. 2018;31:235.
27. Andrade J, Khairy P, Dobrev D, Nattel S. The clinical profile and pathophysiology of atrial fibrillation. *Circ Res*. 2014;114(9):1453–1468.
28. World Medical Association. Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013;310(20):2191–2194.