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ORIGINAL RESEARCH

# Risk Factors and Prognostic Implications of New-Onset Paroxysmal Atrial Fibrillation in Patients Hospitalized with Intracerebral Hemorrhage

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**Objective:** We aimed to assess the prevalence and risk factors of new-onset paroxysmal atrial fibrillation (PAF) in patients hospitalized with ICH and determine whether the new-onset PAF had influenced functional outcomes.

**Methods:** We analyzed a database of all consecutive patients with ICH from October 2013 to May 2022. Univariate and multivariable regression analyses were performed to identify risk factors for new-onset PAF in patients with ICH. Multivariate models were also constructed to assess whether the new-onset PAF was an independent predictor of poor functional outcome, as measured using the modified Rankin scale.

**Results:** This study included 650 patients with ICH, among whom 24 patients had new-onset PAF. In the multivariable model, older age (OR per 10-y increase, 2.26 [95% CI, 1.52–3.35]; $P<0.001$), hematoma volume (OR per 10-mL increase, 1.80 [95% CI, 1.26–2.57]; $P=0.001$), and heart failure (OR, 21.77 [95% CI, 5.52–85.91]; $P<0.001$) were independent risk factors for new-onset PAF. In a sensitivity analysis restricted to 428 patients with N-terminal pro-B-type natriuretic peptide (NT-proBNP), older age, larger hematoma volume, heart failure, and increased NT-proBNP were associated with new-onset PAF. After adjusting for baseline variables, new-onset PAF was an independent predictor of poor functional outcome (OR, 10.35 [95% CI, 1.08–98.80]; $P=0.042$).

**Conclusion:** Older age, larger hematoma volume, and heart failure were independent risk factors for new-onset PAF after ICH. Increased NT-proBNP is correlated with higher risks for new-onset PAF when their information is available at admission. Furthermore, new-onset PAF is a significant predictor of poor functional outcome.

**Keywords:** intracerebral hemorrhage, paroxysmal atrial fibrillation, prognostic implication, risk factors

## Introduction

Atrial fibrillation (AF) is a significant risk factor for cardioembolic stroke.[1] Among patients with embolic stroke of undetermined source (ESUS), paroxysmal AF (PAF) is considered to be the main underlying cause and is detected in 10–30% of these patients.[2,3] Timely detection of PAF after acute ischemic stroke (AIS) has meaningful therapeutic implications; therefore, predictors of PAF in patients with AIS have been widely investigated.[4–7] However, limited data are available regarding the prevalence and risk factors of new-onset PAF after intracerebral hemorrhage (ICH), rather than patients with an ICH secondary to AIS. The rates of new AF in patients with ICH reportedly range from 2.6% to 6%; however, these studies were limited by classifying AF patterns and no risk factor verification.[8–10] Newly diagnosed AF during hospitalization is independently related to an unfavorable 3-month outcome among patients with a cardioembolic stroke.[11] Nevertheless, whether this new-onset, transient, and accidentally discovered AF is associated with poor functional outcome in patients with ICH remains unknown. Thus, this study aimed to investigate the

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prevalence and risk factors of new-onset PAF in patients who were hospitalized for ICH and assess the association between new-onset PAF and functional outcomes at discharge.

# Methods

## Patient Selection

This study enrolled consecutive patients diagnosed with ICH at the First Affiliated Hospitals of Sun Yat-sen University between October 2013 and May 2022. All study procedures were approved by the independent ethics committee of the First Affiliated Hospitals of Sun Yat-sen University, and obtaining informed consent from patients was not required due to its retrospective nature. The inclusion criteria were (1) Age ≥18 years; (2) Evidence of cerebral hemorrhage on head computed tomography (CT); (3) Onset time of less than 7 days; (4) At least 24 hours of continuous stroke unit electrocardiography monitoring (CEM); and (5) Modified Rankin Scale (mRS) score ≤1 prior to ICH. Patients were excluded if they met one or more of the following criteria: (1) Surgery before admission; (2) Hospital stay less than 24 hours; (3) Post-cardiopulmonary resuscitation; (4) History of AF; (5) Traumatic ICH; (6) A recent cerebral ischemia (<3 months); and (7) Isolated intraventricular hemorrhage (IVH).

## Data Collection

Baseline clinical information, including gender, age, systolic blood pressure (SBP), pneumonia, surgical interventions, intensive care unit (ICU) admission, duration of CEM, and length of hospital stay were extracted. Blood tests on admission were available for creatinine, N-terminal pro-B-type natriuretic peptide (NT-proBNP), and glucose levels. Hypertension was defined as a medical history of hypertension or systolic BP ≥140mm Hg or diastolic BP ≥90mm. Diabetes mellitus was defined by a fasting blood glucose ≥7.0mmol/L or postprandial blood glucose ≥11.1mmol/L or HbA1c ≥7% or a medical history of diabetes. Smoking status was based on self-report and defined as current smoker, never smoker, or past smoker. Coronary heart disease was defined as a medical history of myocardial infarction or coronary revascularization.[12] Heart failure was defined by the presence of symptoms and signs of heart failure, and one of the following diagnostic criteria: a plasma NT-proBNP ≥125 ng/L or a left ventricular ejection fraction (LVEF) ≤40%.[13]

AF episodes were evaluated by CEM with an automated detection of AF. All episodes of AF were confirmed by a trained neurologist and classified as having paroxysmal or sustained AF according to the 2010 European Society of Cardiology guidelines for the management of AF.[14] We defined new-onset PAF as AF that was detected during the hospitalization of patients who had no history of AF and that terminated spontaneously within 7 days of onset.

The baseline head CT was assessed by two independent neurologists. We determined the location of the insula based on the identification of the Alberta stroke program early CT score region.[15] We considered that the insula was damaged when it was directly involved or deformation was caused by the mass effect of ICH.[10] Hematoma location was determined and classified as follows: lobar (occipital, parietal, temporal, and frontal), deep (basal ganglia and thalamus), and infratentorial (cerebellar and brainstem). The ABC/2 method was used to measure the hematoma volume.[16] In addition, the presence of IVH and/or subarachnoid hemorrhage (SAH) was documented.

## Evaluation of Clinical Outcomes

The Glasgow Coma Scale (GCS) score was used to assess the clinical status at the time of patient admission. Functional outcomes at discharge were assessed using the mRS on a scale of 0–6. Outcomes were dichotomized into good functional outcome, indicated by an mRS of 0–3, and poor functional outcome, indicated by an mRS of 4–6.[17,18]

## Statistical Analysis

Continuous variables with a normal distribution are expressed as mean ± standard deviation, while not normally distributed data are presented as medians with interquartile ranges, and differences between groups are assessed using the Student's *t*-test or Wilcoxon rank-sum test, respectively. Categorical variables are presented as frequencies with percentages and compared using Pearson's chi-square test or Fisher's exact test. Potential risk factors for new-onset PAF were selected based on medical judgment and were assessed using univariate analysis, and a multivariable regression

model based on a set of all potential predictors (P > 0.1) using forward selection was created. The multivariable regression model was used for a subset of patients with NT-proBNP data.

To analyze ICH outcomes at discharge, we performed multivariate logistic regression to investigate whether new-onset PAF was an independent predictor for poor functional outcome. The variables for the models initially included variables related to poor functional outcome in the univariate analysis, and we subsequently performed a forward stepwise selection procedure. All statistical analyses were performed using the R software (version 4.1.1), and significance was set at P values <0.05.

# Results

## Baseline Characteristics of Patients with and without New-Onset PAF

Among 1656 patients who were diagnosed with ICH, 650 patients met the inclusion criteria, and their data were included in the final analysis (Figure 1). Baseline characteristics of 650 patients with ICH stratified by new-onset PAF are summarized in Table 1. New-onset PAF was detected in 24 (3.7%) patients, and all of them admitted within 3 days of symptoms onset. Patients with new-onset PAF were older and more likely to have heart failure, pneumonia, and longer duration of ECM. Regarding the radiological information, the presence of IVH and larger hematoma volume were significantly more frequent in patients with new-onset PAF. Furthermore, patients with new-onset PAF had higher mRS at discharge and lower GCS scores on admission than patients without new-onset PAF. Information on baseline NT-proBNP levels was available for 428 patients. The median NT-proBNP levels were 647 (268–2328) pg/mL and 160 (69–514) pg/mL in patients with and without new-onset PAF, respectively ($P$<0.001; Table 1).

## Risk Factors for New-Onset PAF

The univariable risk factors for new-onset PAF in patients with ICH are shown in Table 2. Older age (odds ratio [OR] per 10-y increase, 2.50 [95% CI, 1.69–3.68]; $P$<0.001), larger hematoma volume (OR per 10-mL increase, 1.63 [95% CI, 1.19–2.24]; $P$=0.003), heart failure (OR, 29.48 [95% CI, 9.00–96.59]; $P$<0.001), and duration of ECM (OR, 1.03 [95% CI, 1.01–1.05]; $P$=0.011) were significantly associated with new-onset PAF.

The results of the multivariable analyses are presented in Table 3. Significant risk factors included older age (OR per 10-y increase, 2.26 [95% CI, 1.52–3.35]; $P$<0.001), larger hematoma volume (OR per 10-mL increase, 1.80 [95% CI, 1.26–2.57]; $P$=0.001), and heart failure (OR, 21.77 [95% CI, 5.52–85.91]; $P$<0.001).

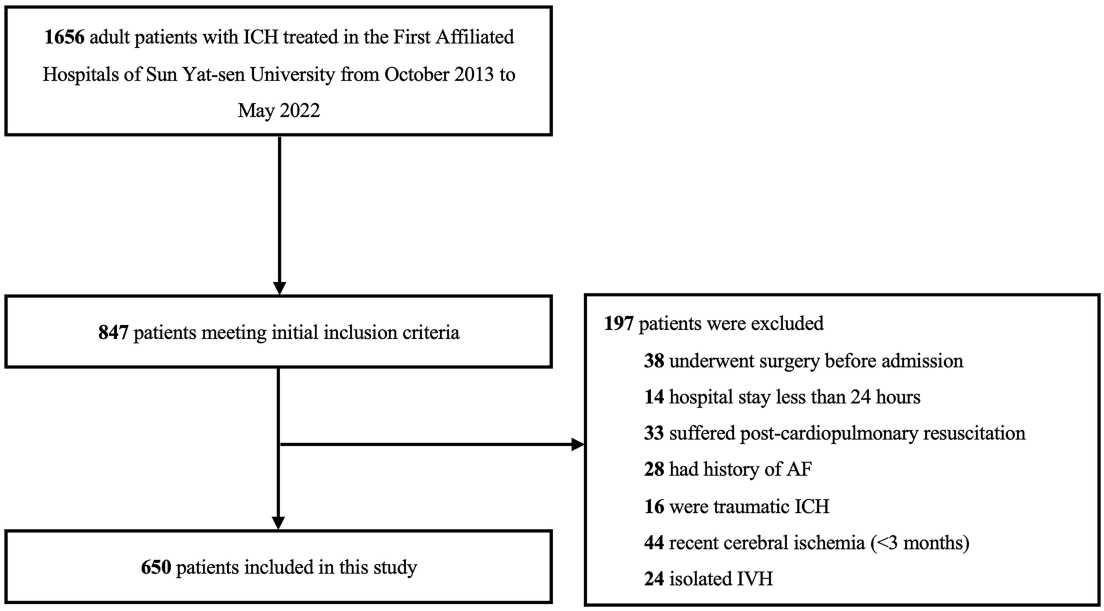


**Figure 1** Study flow chart.
**Abbreviations**: ICH, intracerebral hemorrhage; AF, atrial fibrillation; IVH, intraventricular hemorrhage.

**Table 1** Baseline Characteristics of Patients with Intracerebral Hemorrhage with and without New-Onset PAF

| Characteristics | Patients without PAF N=626 | Patients with PAF N=24 | *P* value |
|---|---|---|---|
| Gender, female, n (%) | 201 (32.1%) | 8 (33.3%) | 0.899 |
| Age, years (mean ± SD) | 60.2 ± 14.4 | 74.0 ± 12.0 | <0.001 |
| ICU admission, n (%) | 117 (18.7%) | 8 (33.3%) | 0.074 |
| Time from symptom onset to admission | | | |
| <24 hours | 121 (19.3%) | 10 (41.7%) | 0.016 |
| 1–3 day | 412 (65.8%) | 14 (58.3%) | 0.591 |
| 3–7 day | 93 (14.9%) | 0 (0.0%) | 0.036 |
| Hematoma location, n (%) | | | |
| Lobar | 145 (23.2%) | 10 (41.7%) | 0.065 |
| Deep | 396 (63.3%) | 12 (50.0%) | 0.278 |
| Infratentorial | 85 (13.6%) | 2 (8.3%) | 0.758 |
| Insular damage, n (%) | 80 (12.8%) | 6 (25.0%) | 0.083 |
| Hematoma volume, mL; median (IQR) | 10.0 (3.9–25.0) | 31.8 (13.3–61.1) | 0.002 |
| Presence of IVH, n (%) | 189 (30.2%) | 13 (54.2%) | 0.013 |
| Presence of SAH, n (%) | 41 (6.6%) | 3 (12.5%) | 0.217 |
| Hypertension, n (%) | 552 (88.2%) | 22 (91.7%) | 1.000 |
| Diabetes mellitus, n (%) | 145 (23.2%) | 5 (20.8%) | 0.790 |
| Heart failure, n (%) | 7 (1.1%) | 6 (25.0%) | <0.001 |
| Pneumonia, n (%) | 173 (27.6%) | 20 (83.3%) | <0.001 |
| Coronary heart disease, n (%) | 44 (7.0%) | 4 (16.7%) | 0.093 |
| Smoking status: Current, n (%) | 152 (24.3%) | 4 (16.7%) | 0.474 |
| SBP, mmHg; median (IQR) | 154 (140–170) | 152 (136–162) | 0.220 |
| Creatinine, mmol/L; median (IQR) | 78.0 (62.0–100.0) | 94.0 (64.5–147.0) | 0.144 |
| Glucometer, mmol/L; median (IQR) | 6.0 (5.1–7.6) | 6.4 (5.2–8.5) | 0.494 |
| Surgery interventions, n (%) | 68 (10.9%) | 3 (12.5%) | 0.738 |
| In-hospital mortality, n (%) | 24 (3.8%) | 3 (12.5%) | 0.072 |
| Length of hospital stay, day; median (IQR) | 14 (10–20) | 17 (12–32) | 0.126 |
| mRS at discharge, median (IQR) | 4 (2–4) | 4 (4–5) | <0.001 |
| GCS score, median (IQR) | 15 (10–15) | 9 (5–11) | <0.001 |
| Duration of CEM, day; median (IQR) | 9 (5–14) | 15 (9–23) | 0.005 |
| Total patients with baseline NT-proBNP | 405 | 23 | |
| NT-proBNP, pg/mL; median (IQR) | 160 (69–514) | 647 (268–2328) | <0.001 |

**Abbreviations**: PAF, paroxysmal atrial fibrillation; SD, standard deviation; ICU, intensive care unit; IQR, interquartile range; IVH, intraventricular hemorrhage; SAH, subarachnoid hemorrhage; SDP, systolic blood pressure; mRS, modified Rankin score; GCS, Glasgow Coma Scale; CEM, continuous stroke unit electrocardiography monitoring; NT-proBNP, N-terminal prohormone of brain natriuretic peptide.

## Sensitivity Analysis

We performed an analysis of multivariable risk factors for new-onset PAF among 428 patients with baseline NT-proBNP levels, and the results are shown in Table 4. Older age (OR per 10-y increase, 2.16 [95% CI, 1.44–3.24]; *P*<0.001), larger hematoma volume (OR per 10-mL increase, 1.69 [95% CI, 1.17–2.45]; *P*=0.005), heart failure (OR, 8.35 [95% CI, 1.91–36.55]; *P*=0.005), and higher NT-proBNP levels (OR per 1-U increase on log scale, 1.32 [95% CI, 1.00–1.73]; *P*=0.049) were independently associated with new-onset PAF. There was no statistically significant interaction between heart failure and NT-proBNP.

## New-Onset PAF and Functional Outcomes at Discharge

The characteristics of the included patients stratified by functional outcomes at discharge are shown in Table 5. Compared with patients with good functional outcome, new-onset PAF was significantly more frequent in patients with poor functional outcome (0.32% vs 6.82%, *P*<0.001).

**Table 2** Univariable Regression Model of Risk Factors for New-Onset PAF in Patients with Intracerebral Hemorrhage

| Variables | OR (95% CI) | *P* value |
|---|---|---|
| Gender, female | 0.95 (0.40–2.25) | 0.900 |
| Age (per 10-y increase) | 2.50 (1.69–3.68) | <0.001[a] |
| Insular damage | 2.27 (0.88–5.90) | 0.091[b] |
| Hematoma volume (per 10-mL increase) | 1.63 (1.19–2.24) | 0.003[a] |
| Coronary heart disease | 2.65 (0.87–8.08) | 0.088[b] |
| Hypertension | 1.47 (0.34–6.40) | 0.604 |
| Diabetes mellitus | 0.87 (0.32–2.38) | 0.791 |
| Heart failure | 29.48 (9.00–96.59) | <0.001[a] |
| Duration of CEM | 1.03 (1.01–1.05) | 0.011[a] |

**Notes**: [a]Significant at P<0 0.05. [b]Significant at P<0.1 (cutoff for inclusion in multivariable models).
**Abbreviations**: OR, odds ratio; CI, confidence interval; CEM, continuous stroke unit electrocardiography monitoring.

**Table 3** Multivariate Logistic Regression Analyses of Risk Factors for New-Onset PAF Among Patients with Intracerebral Hemorrhage

| Variables | OR (95% CI) | *P* value |
|---|---|---|
| Age (per 10-y increase) | 2.26 (1.52–3.35) | <0.001 |
| Hematoma volume (per 10-mL increase) | 1.80 (1.26–2.57) | 0.001 |
| Heart failure | 21.77 (5.52–85.91) | <0.001 |

**Abbreviations**: OR, odds ratio; CI, confidence interval.

**Table 4** Sensitivity Analysis: Multivariable Analyses of Risk Factors for New-Onset PAF Restricted to Patients with Baseline NT-proBNP Levels (n = 428)

| Variables | OR (95% CI) | *P* value |
|---|---|---|
| Age (per 10-y increase) | 2.16 (1.44–3.24) | <0.001 |
| Hematoma volume (per 10-mL increase) | 1.69 (1.17–2.45) | 0.005 |
| Heart failure | 8.35 (1.91–36.55) | 0.005 |
| NT–proBNP (per 1-U increase on log scale) | 1.32 (1.00–1.73) | 0.049 |

**Abbreviations**: OR, odds ratio; CI, confidence interval; NT-proBNP, N-terminal prohormone of brain natriuretic peptide.

Univariable analysis was performed to define the predictors of poor functional outcome at discharge, and the results are shown in Table 6. In the multivariate analysis, new-onset PAF (OR, 10.35 [95% CI, 1.08–98.8]; *P*=0.042), larger hematoma volume (OR per 10–mL increase, 1.30 [95% CI,1.05–1.60]; *P*=0.016), heart failure (OR, 10.81 [95% CI, 1.09–107.38]; *P*=0.042), pneumonia (OR, 1.93 [95% CI, 1.11–3.34]; *P*=0.019), and lower GCS scores (OR, 0.51 [95% CI, 0.44–0.58]; *P*<0.001) were independent predictors of poor functional outcome in patients with ICH (Table 6).

## Discussion

In this study of patients with ICH, 24 (3.7%) cases of new-onset PAF were detected during hospitalization. Older age, larger hematoma volume, and heart failure were associated with a higher risk for new-onset PAF in patients with ICH. When NT-proBNP was available, older age, larger hematoma volume, heart failure, and increased NT-proBNP levels were independent risk factors for new-onset PAF. Furthermore, new-onset PAF was independently associated with poor functional outcome at discharge.

Previous studies have mainly focused on the PAF detection in patients with AIS, especially in those diagnosed with ESUS.[19,20] Nevertheless, few studies have specifically investigated the prevalence of PAF in patients with ICH. In our study, 3.7% of patients had new-onset PAF detection after ICH during hospitalization. The results presented are comparable to those of a study of unselected patients with AIS and revealed that new AF was detected in 68 of 1717 patients (4.0%) after monitoring using usual

**Table 5** Characteristics of Patients with Intracerebral Hemorrhage Stratified by Functional Outcomes at Discharge

| Characteristics | Good Outcome N=313 | Poor Outcome N=337 | *P* value |
|---|---|---|---|
| Gender, female, n (%) | 98 (31.3%) | 111 (32.9%) | 0.657 |
| Age, years (mean ± SD) | 60.2 ± 14.1 | 61.2 ± 14.9 | 0.349 |
| New-onset PAF, n (%) | 1 (0.3%) | 23 (6.8%) | <0.001 |
| ICU admission, n (%) | 11 (3.5%) | 114 (33.8%) | <0.001 |
| Hematoma location, n (%) | | | |
| Lobar | 80 (25.6%) | 75 (22.3%) | 0.370 |
| Deep | 188 (60.1%) | 220 (65.3%) | 0.196 |
| Infratentorial | 45 (14.4%) | 42 (12.5%) | 0.548 |
| Insular damage, n (%) | 17 (5.4%) | 69 (20.5%) | <0.001 |
| Hematoma volume, mL; median (IQR) | 6.0 (2.4–14.0) | 17.2 (7.3–41.8) | <0.001 |
| Presence of IVH, n (%) | 56 (17.9%) | 146 (43.3%) | <0.001 |
| Presence of SAH, n (%) | 11 (3.5%) | 33 (9.8%) | 0.001 |
| Hypertension, n (%) | 269 (85.9%) | 305 (90.5%) | 0.071 |
| Diabetes mellitus, n (%) | 67 (21.4%) | 83 (24.6%) | 0.330 |
| Heart failure, n (%) | 1 (0.3%) | 12 (3.6%) | 0.003 |
| Pneumonia, n (%) | 37 (11.8%) | 156 (46.3%) | <0.001 |
| Coronary heart disease, n (%) | 25 (8.0%) | 23 (6.8%) | 0.571 |
| SBP, mmHg, median (IQR) | 153 (138–169) | 156 (140–170) | 0.245 |
| Creatinine, mmol/L; median (IQR) | 74 (62–94) | 82 (63–105) | 0.010 |
| Glucometer, mmol/L; median (IQR) | 5.5 (4.8–6.8) | 6.7 (5.6–8.1) | <0.001 |
| Surgery interventions, n (%) | 12 (3.8%) | 59 (17.5%) | <0.001 |
| Length of hospital stay, day; median (IQR) | 12 (9–15) | 16 (12–25) | <0.001 |
| GCS scores, median (IQR) | 15 (15–15) | 10 (6–14) | <0.001 |

**Abbreviations**: SD, standard deviation; PAF, paroxysmal atrial fibrillation; ICU, intensive care unit; IQR, interquartile range; IVH, intraventricular hemorrhage; SAH, subarachnoid hemorrhage; SBP, systolic blood pressure; GCS, Glasgow Coma Scale.

**Table 6** Univariable and Multivariable Regression Model of Predictors of Poor Functional Outcome at Discharge in Patients with Intracerebral Hemorrhage

| Variables | Univariable OR (95% CI) | *P* value | Multivariable[a] OR (95% CI) | *P* value |
|---|---|---|---|---|
| Gender, female | 1.08 (0.77–1.50) | 0.657 | | |
| Hematoma volume (per 10-mL increase) | 2.05 (1.76–2.39) | <0.001 | 1.30 (1.05–1.60) | 0.016 |
| Age (per 10-y increase) | 1.08 (0.93–1.25) | 0.330 | | |
| New-onset PAF | 22.85 (3.07–170.20) | <0.001 | 10.35 (1.08–98.80) | 0.042 |
| Heart failure | 11.52 (1.49–88.99) | 0.019 | 10.81 (1.09–107.38) | 0.042 |
| Pneumonia | 6.43 (4.29–9.63) | <0.001 | 1.93 (1.11–3.34) | 0.019 |
| Glucometer | 1.11 (1.04–1.19) | 0.001 | | |
| GCS scores | 0.47 (0.41–0.54) | 0.001 | 0.51 (0.44–0.58) | <0.001 |
| Presence of IVH | 3.51 (2.45–5.03) | <0.001 | | |
| Hematoma location | | | | |
| Deep | Ref | Ref | | |
| Lobar | 0.80 (0.50–1.27) | 0.339 | | |
| Infratentorial | 0.80 (0.55–1.16) | 0.241 | | |
| Insular damage | 4.48 (2.57–7.82) | <0.001 | | |
| ICU admission | 14.04 (7.38–26.68) | <0.001 | | |
| Presence of SAH | 2.98 (1.48–6.01) | 0.002 | | |
| Surgery interventions | 5.32 (2.80–10.11) | <0.001 | | |

**Notes**: [a]Variables from univariate logistic regression with P < 0.1 were included in multivariate logistic regression model using a forward stepwise logistic regression analysis and removed with P > 0.05.

**Abbreviations**: OR, odds ratio; CI, confidence interval; PAF, paroxysmal atrial fibrillation; GCS, Glasgow Coma Scale; IVH, intraventricular hemorrhage; Ref, reference; ICU, intensive care unit; SAH, subarachnoid hemorrhage.

diagnostic procedures in the hospital.[21] Furthermore, another study using at least 24 h of rhythm monitoring in patients with AIS aged ≥60 years reported slightly higher rates of new AF detection than our results.[22] Although there are no data regarding the differences in the prevalence of new-onset PAF in patients with ICH versus to that in patients with AIS, our study suggests that new-onset PAF is not uncommon in patients with ICH, and this needs to be further investigated.

Our study demonstrated that older age, heart failure and increased NT-proBNP were independently associated with the risk of developing new-onset PAF in patients with ICH. This result is in line with results of previous studies conducted among patients with AIS and in high-risk populations.[5,7,23–26] Interestingly, we found that larger hematoma volume was significantly associated with the incidence of new-onset PAF after ICH. However, the exact underlying mechanisms remain unclear. Inflammation and its associated immune responses play an important role in AF pathogenesis.[27] When ICH occurs, a pronounced inflammatory reaction occurs immediately, which is characterized by the breakdown of the blood–brain barrier,[28] activation of microglia, and production of inflammatory factors.[29–31] Therefore, new-onset PAF may be a complication of systemic inflammation following ICH. Furthermore, autonomic dysregulation has been observed in patients with ICH, with decreased heart rate variability and baroreflex sensitivity.[32,33] Evidence from clinical studies and animal models revealed that autonomic dysfunction contributes to atrial electrical and structural remodeling, thereby increasing AF inducibility.[34–38] Altogether, these data indicate that systemic inflammation and autonomic dysfunction may be the important pathophysiology of new-onset PAF in patients with ICH.

Our study showed that the new-onset PAF is an independent predictor of poor functional outcome after ICH. However, it remains unknown whether new-onset PAF in these patients is a direct cause of poor functional outcome or just a marker of disease severity. It is well known that AF can trigger or worsen heart failure, then leading to reduced cardiac output.[39] Although the duration of AF episodes was relatively short, the adverse hemodynamic consequences may persist after AF episodes terminated.[40] Therefore, this effect could be harmful for patients who were diagnosed with new-onset PAF after ICH. In addition, although new-onset PAF remained significantly associated with poor functional outcome after adjusting for potential confounders, the magnitude of the correlation was obviously diminished, indicating that the poor functional outcome can be affected by other risk factors. Consistent with previous studies,[41–43] we found that hematoma volume, pneumonia, heart failure, and lower GCS scores were strongly correlated with poor functional outcome after ICH. Therefore, they may explain most of the association between new-onset PAF and poor functional outcome. Nevertheless, screening for new-onset PAF among patients with high-risk ICH remains important, and further studies are needed to determine the risk of ischemic stroke and optimal management of these patients.

Our study had some limitations. First, the incidence of PAF after ICH may be underestimated, because of the lack of an AF detection workup and standardized use of long-term cardiac monitoring during hospitalization. Second, although the patients diagnosed with recent cerebral ischemia were not included, we could not exclude the possibility that some patients may have occult PAF before a stroke event. Finally, this was a retrospective, single-center study with a small sample size and low number of events. To further validate these findings, a multicenter prospective study with more patients and a longer follow-up period is required.

## Conclusion

In this study, older age, larger hematoma volume, and heart failure were independent risk factors of new-onset PAF in patients with ICH. When data on NT-proBNP were available, increased NT-proBNP levels were also associated with a higher likelihood of detecting new-onset PAF. Furthermore, new-onset PAF was predictive of poor functional outcome after ICH. However, because of the retrospective nature and small sample size of this study, further investigations are needed.

## Abbreviations

AF, atrial fibrillation; ICH, intracerebral hemorrhage; PAF, paroxysmal atrial fibrillation; NT-proBNP, N-terminal pro-B-type natriuretic peptide; AIS, acute ischemic stroke; CEM, continuous stroke unit electrocardiography monitoring; IVH, intraventricular hemorrhage; SAH, subarachnoid hemorrhage; SBP, systolic blood pressure; ICU, intensive care unit; GCS, Glasgow Coma Scale; OR, odds ratio; CI, confidence interval.

## Ethics Statement

The study was performed according to the Declaration of Helsinki guidelines and was approved by the independent ethics committee of the First Affiliated Hospitals of Sun Yat-sen University. Written informed consent from patients was not required due to its retrospective nature, and all data used in this study was anonymized.

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## Disclosure

The authors report no conflicts of interest in this work.

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