

Incidence and risk factors of postoperative atrial fibrillation in cardiac surgery patients: A multicenter observational study from Thailand

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Abstract

Background

Postoperative atrial fibrillation (POAF) is a common complication after cardiac surgery, increasing morbidity, resource use, and healthcare costs. Data on POAF in Southeast Asian populations remain limited. This multicenter observational study aimed to determine the incidence of POAF, identify risk factors among cardiac surgery patients in Thailand, and propose a simple clinical risk framework for preoperative risk stratification.

Methods

We conducted this retrospective cohort study at three cardiac surgical centers in Thailand from January 2021 to December 2023. Adult patients undergoing cardiac valve surgery or coronary artery bypass grafting (CABG) were included. The primary outcome was the incidence of POAF, defined as new-onset atrial fibrillation requiring treatment within the first 72 postoperative hours. We also identified risk factors.

Results

Of 408 enrolled patients, 100 (24.5%) developed POAF. Patients with POAF had significantly longer mechanical ventilation duration (25.9 ± 26.3 vs. 19.8 ± 21.4 hours, $p = 0.047$), intensive care unit (ICU) stay (119.7 ± 80.6 vs. 82.3 ± 47.9 hours, $p < 0.001$), and hospital stay (13.8 ± 5.9 vs. 11.3 ± 4.6 days, $p < 0.001$). In multivariate analysis ($n = 408$), preoperative atrial fibrillation (OR = 5.364, 95% CI: 2.845–10.113, $p < 0.001$) and electrolyte imbalance (OR = 1.987, 95% CI: 1.177–3.354, $p = 0.010$) were independent predictors of POAF; the two-variable model had an AUC of 0.673 (95% CI 0.607–0.739, $p < 0.001$). The observed POAF incidence increased monotonically across a proposed 4-tier risk score: 15.9% (neither factor), 24.8% (electrolyte imbalance alone), 42.1% (preoperative AF alone), and 85.7% (both factors present). Hypokalemia, the predominant individual electrolyte abnormality, was not independently associated with POAF in subgroup analysis (OR = 1.457, 95% CI: 0.880–2.412, $p = 0.142$).

Conclusions

The POAF incidence was 24.5%. Preoperative atrial fibrillation and electrolyte imbalance were significant independent risk factors. Electrolyte imbalance is modifiable and can be addressed proactively to reduce POAF. A simple additive score based on these two factors showed a clear gradient in observed risk and could form the basis of a preoperative screening approach pending prospective validation.

Introduction

Patients undergoing cardiac surgery are often elderly, have multiple comorbidities, and undergo complex procedures involving cardiopulmonary bypass, placing them at high risk for postoperative complications. The Society of Thoracic Surgeons has identified five major postoperative complications after cardiac surgery: atrial fibrillation, renal failure, prolonged ventilation (> 24 hours), stroke, and deep sternal wound infection¹.

POAF is one of the most common complications after cardiac surgery, with reported incidence ranging from 15–40% overall², 15–30% after isolated valve surgery, and 18–74% after CABG³, depending on the population and monitoring method. POAF typically occurs 2–4 days postoperatively and is linked to hemodynamic instability, thromboembolism, prolonged hospitalization, and mortality^{3,4}. Beyond the index hospitalization, POAF has been independently associated with an increased long-term risk of stroke and death that persists for years after surgery^{5,6}, as well as substantially higher hospital costs — ranging from approximately US\$3,000 to over US\$20,000 per patient, depending on the healthcare system and cost components analyzed⁷. Notably, a Thai single-center cost analysis quantified this economic burden in a local healthcare setting, finding attributable costs of 48,000–72,000 Thai Baht (approximately US\$1,600–2,400) per patient, depending on surgery type⁸, underscoring that this complication carries direct, locally relevant economic implications in addition to its clinical consequences.

Proposed mechanisms include: (1) atrial structural/electrical remodeling from elevated atrial pressure⁹; (2) systemic inflammatory response to surgery and cardiopulmonary bypass³; (3) excessive autonomic activation from blood loss, pain, beta-blocker withdrawal, and electrolyte disturbance^{10,11}; (4) pericardial/myocardial inflammation post-bypass (3); and (5) pulmonary venous or atrial triggers¹¹.

Despite this substantial clinical and economic burden, effective prevention remains incomplete. Beta-blockers, sotalol, amiodarone, and magnesium have each demonstrated efficacy in reducing POAF incidence across randomized trials and meta-analyses^{12,13}, yet no single agent or combination has eliminated the complication entirely. This underscores the ongoing need to identify and target modifiable patient-level risk factors — such as electrolyte status — alongside established pharmacologic prophylaxis, rather than relying on prevention strategies alone.

Most large POAF risk-factor studies derive from Western cohorts. A multiethnic Singaporean model (n = 2,168) reported 17.3% POAF incidence, with age ≥ 65, prior AF, inotrope use, CPB > 120 minutes, and ethnicity as independent predictors — notably finding that clinical predictors resembled Western data, while ethnicity itself modified risk¹⁴. A Taiwanese propensity-matched cohort further demonstrated that POAF is associated with increased long-term risk of recurrent atrial fibrillation, heart failure, and mortality, underscoring that its clinical significance extends well beyond the index hospitalization¹⁵. No prior multicenter study has specifically examined POAF incidence and risk factors in a Thai population.

This study aimed to (1) determine POAF incidence across three Thai centers, (2) identify independent risk factors, and (3) develop and internally examine a simple, clinically actionable preoperative risk framework.

Methods

Study Design and Setting

This retrospective cohort study was conducted at Srinagarind Hospital, Queen Sirikit Heart Center of the Northeast, and Surat Thani Hospital. The study was approved by the Khon Kaen University Ethics Committee for Human Research (HE671492) and the Surat Thani Hospital Ethics Committee for Human Research (REC67-0111), and conducted in accordance with the Declaration of Helsinki. Because this retrospective study uses anonymized data, the ethics committees waived informed consent. This report follows the STROBE checklist for cohort studies.

Study Population

Adults (≥ 18 y) underwent valve surgery or CABG between January 2021 and December 2023. Excluded were aortic surgery, maze procedure, incomplete records, preoperative mechanical circulatory support, or intraoperative or 3-day postoperative death. A total of 408 patients met eligibility criteria and were included in the analysis, with complete data available for all variables used in the primary and multivariate analyses.

Data Collection

We abstracted data retrospectively from electronic and paper medical records using a standardized case-report form and de-identified the data with sequential IDs. All 408 enrolled patients had complete data for the two final independent predictors (preoperative atrial fibrillation and electrolyte imbalance) and for the primary outcome; no patients were excluded from Tables 1–5 because of missing data on these key variables.

Variables collected: demographics; comorbidities; preoperative labs; surgical type; perioperative timing variables; fluid/blood product administration; and outcomes (ventilator time, ICU stay, and hospital stay).

Definitions

- POAF: New-onset AF requiring treatment within 72 hours postoperatively.
- Valve surgery: Repair or replacement of diseased valves.
- CABG: Bypass of coronary blockages using venous or arterial conduits (on- or off-pump).

- Electrolyte imbalance: Abnormal serum levels of sodium, potassium, calcium, or magnesium during the perioperative period, analyzed as a composite variable. We performed a post hoc subgroup analysis for hypokalemia, as it was the predominant electrolyte abnormality in this cohort; other individual electrolyte abnormalities (hyponatremia, hypocalcemia, hypomagnesemia) occurred in fewer than 10 patients, precluding separate meaningful analysis.

Statistical Analysis

Continuous variables: mean $\pm$ SD, compared using a t-test. Categorical variables: n (%), compared using chi-square or Fisher's exact test. We entered univariate predictors with $p < 0.2$ into multivariate logistic regression. We calculated AUC-ROC for individual candidate predictors and the combined final multivariate model. We constructed a simple additive, point-based risk score from the two independent multivariate predictors and cross-tabulated it directly against observed POAF status. Significance: $p < 0.05$.

We calculated the sample size a priori using the formula $N = 50 + 10k$, following a previously described method for logistic regression sample size estimation¹⁶. Here, k is the number of candidate clinical predictors identified in the literature review ($k = 20$), yielding a minimum of 275 after accounting for a 10% dropout rate. The final enrolled cohort ($n = 408$) exceeded this pre-specified minimum, providing an adequate participant-to-predictor ratio for the multivariate model.

Results

Patient Characteristics

We enrolled 408 patients undergoing cardiac surgery, of whom 100 (24.5%) developed POAF (Table 1). The groups did not differ significantly by sex, age, BMI, ejection fraction, functional class, ASA classification, or surgical type.

Preoperative AF was significantly more common in the POAF group (34.0% vs. 8.1%, $p < 0.001$). Other comorbidities did not differ significantly. Electrolyte imbalance was more common in the POAF group (47.0% vs. 29.5%, $p = 0.002$). POAF patients had lower creatinine (1.1 ± 0.5 vs. 1.4 ± 1.4 mg/dL, $p = 0.023$) and lower platelet counts (227.0 ± 69.7 vs. $247.3 \pm 85.3 \times 10^3$, $p = 0.035$). Other laboratory values, perioperative timing, P/F ratios, lactate, and fluid/blood administration were comparable.

Hypokalemia was the most common electrolyte abnormality in this cohort, affecting 100 of 408 patients (24.5%). In the individual analysis, hypokalemia was associated with higher odds of POAF but did not reach statistical significance (30/100 [30.0%] of hypokalemic patients developed POAF vs. 70/308 [22.7%] of normokalemic patients; $\chi^2 = 2.158$, $p = 0.142$; Fisher's exact $p = 0.144$; OR = 1.457, 95% CI: 0.880–2.412).

Table 1. Demographic and clinical characteristics of patients in each group (n=408)

	POAF (n=100)	non-POAF (n=308)	P value
Sex (male)	59 (64.1)	198 (66.9)	0.627
Age (y)	63.7 ± 9.5	61.9 ± 10.6	0.138
BMI (kg/m ²)	23.7 ± 4.0	24.0 ± 4.1	0.454
Ejection fraction (%)	55.9 ± 14.7	56.2 ± 15.9	0.840
Type of surgery:	50 (50.0)	131 (42.5)	0.204
Valve			
Non-valve	50 (50.0)	177 (57.5)	
Hypertension	68 (68.0)	202 (65.6)	0.716
Diabetes mellitus	36 (36.0)	119 (38.6)	0.722
Myocardial ischemia	35 (35.0)	138 (44.8)	0.103
Dyslipidemia	40 (40.0)	124 (40.3)	1.000
Congestive heart failure	9 (9.0)	44 (14.3)	0.230
Preoperative atrial fibrillation	34 (34.0)	25 (8.1)	<0.001*
AV block	0 (0.0)	3 (1.0)	1.000
Chronic kidney disease	17 (17.0)	63 (20.5)	0.562
Old CVA	8 (8.0)	29 (9.4)	0.841
Liver impairment	2 (2.0)	2 (0.6)	0.253
Vascular disease	12 (12.0)	24 (7.8)	0.223
Anemia	11 (11.0)	35 (11.4)	1.000
Coagulopathy	5 (5.0)	15 (4.9)	1.000
Electrolyte imbalance	47 (47.0)	91 (29.5)	0.002*
Creatinine (mg/dL)	1.1 ± 0.5	1.4 ± 1.4	0.023*
Sodium (mEq/L)	138.4 ± 2.8	138.0 ± 3.4	0.398
Potassium (mEq/L)	4.1 ± 0.5	4.2 ± 0.4	0.855
Blood sugar (mg/dL)	118.6 ± 42.1	123.1 ± 47.1	0.415
Hemoglobin (g/dL)	12.2 ± 1.8	12.2 ± 2.0	0.952
Hematocrit (%)	37.0 ± 5.2	37.0 ± 5.7	0.998
Albumin (g/dL)	4.0 ± 0.5	4.1 ± 0.5	0.359

	POAF (n=100)	non-POAF (n=308)	P value
Platelet count ($\times 10^3$)	227.0 $\pm$ 69.7	247.3 $\pm$ 85.3	0.035*
PT (sec)	12.5 $\pm$ 2.3	12.3 $\pm$ 2.8	0.565
INR	1.1 $\pm$ 0.2	1.1 $\pm$ 0.3	0.800
PTT (sec)	30.1 $\pm$ 7.0	29.3 $\pm$ 5.8	0.241
Anesthesia time (min)	398.8 $\pm$ 93.8	383.7 $\pm$ 87.7	0.151
CPB time (min)	158.5 $\pm$ 84.8	159.7 $\pm$ 83.0	0.854
Aortic clamp time (min)	97.1 $\pm$ 34.4	98.1 $\pm$ 34.7	0.827
Operation time (min)	324.6 $\pm$ 89.6	313.4 $\pm$ 83.7	0.277
PRC post-bypass (unit)	2.2 $\pm$ 1.2	1.9 $\pm$ 0.9	0.089
FFP post-bypass (unit)	2.5 $\pm$ 1.1	2.5 $\pm$ 1.2	0.932

Values are presented as mean $\pm$ SD or as n (%). POAF = postoperative atrial fibrillation; BMI = body mass index; A-V = atrioventricular; CVA = cardiovascular accident; PT = prothrombin time; INR = International Normalized Ratio; PTT = Partial Thromboplastin Time; CPB = cardiopulmonary bypass; PRC = packed red cells; FFP = fresh frozen plasma.

Clinical Outcomes

POAF patients had longer durations of mechanical ventilation, ICU stay, and hospital stay than non-POAF patients (Table 2).

Table 2. Clinical outcomes of patients in each group (n=408)

	POAF (n=100)	non-POAF (n=308)	Mean diff.	95% CI	P value
Mechanical ventilator time (h)	25.9 $\pm$ 26.3	19.8 $\pm$ 21.4	6.0	0.1 to 12.0	0.047*
ICU stay (h)	119.7 $\pm$ 80.6	82.3 $\pm$ 47.9	37.3	19.9 to 54.8	<0.001*
Hospital stay (d)	13.8 $\pm$ 5.9	11.3 $\pm$ 4.6	2.5	1.2 to 3.8	<0.001*

Risk Factors

Univariate analysis (Table 3): preoperative AF and electrolyte imbalance were significant; valve surgery, creatinine ≥ 0.8 , PRC ≥ 2 units, and FFP ≥ 1 unit met the $p < 0.2$ threshold for multivariate inclusion.

Table 3. Univariate analysis (n=408)

	AUC-ROC	OR	P value
Preoperative atrial fibrillation	0.629	5.832	<0.001
Electrolyte imbalance	0.584	2.056	0.002
Valve surgery	0.536	1.351	0.204
Creatinine ≥ 0.8 mg/dL	0.520	0.839	0.255
PRC post-bypass ≥ 2 units	0.530	1.333	0.247
FFP post-bypass ≥ 1 unit	0.519	1.535	0.219

Multivariate analysis (Table 4): preoperative AF (OR=5.364, 95% CI 2.845–10.113, $p < 0.001$) and electrolyte imbalance (OR=1.987, 95% CI 1.177–3.354, $p = 0.010$) remained independent predictors in the complete cohort of 408 patients with no missing data on either predictor.

Table 4. Multivariate analysis (n=408)

	OR	95% CI	P value
Preoperative atrial fibrillation	5.364	2.845 to 10.113	<0.001
Electrolyte imbalance	1.987	1.177 to 3.354	0.010

The combined multivariate model (preoperative AF + electrolyte imbalance) demonstrated an area under the ROC curve (AUC) of 0.673 (SE 0.034, 95% CI 0.607–0.739, $p < 0.001$) for predicting POAF (Figure 1, Table 5). Because both retained predictors are binary, the model generates only four distinct predicted-probability strata, reflected in the stepped shape of the ROC curve, with results fully consistent with the directly observed 4-tier risk stratification (Table 6) – including an exact match between the ROC-derived sensitivity/specificity at each threshold (Table 5) and the values directly cross-tabulated from raw patient counts (Table 7).

Table 5. ROC coordinates for the combined multivariate model

Predicted probability cutoff	Sensitivity	Specificity	Youden index
≥0.000	1.000	0.000	0.000
≥0.212	0.630	0.629	0.259
≥0.398	0.340	0.921	0.261 (optimal)
≥0.611	0.180	0.990	0.170
≥1.000	0.000	1.000	0.000

Table 6. Observed POAF incidence by proposed risk score (n=408)

Risk Factors Present	Score	n	POAF, n (%)	OR vs. score 0 (95% CI)
Neither	0	232	37 (15.9%)	Reference
Electrolyte imbalance only	1	117	29 (24.8%)	1.74 (1.00–3.00)
Preoperative AF only	3	38	16 (42.1%)	3.83 (1.84–7.99)
Both	4	21	18 (85.7%)	31.6 (8.9–112.7)*

**Wide confidence interval reflects small stratum size (n=21, only 3 non-POAF); interpret with caution. This scoring framework is hypothesis-generating and requires prospective external validation before clinical use.*

Proposed Simplified Clinical Risk Framework

We constructed a simple 4-tier additive risk score (0, 1, 3, 4 points; Table 6), weighted approximately proportional to $\ln[\text{adjusted OR}]$, analogous to established clinical risk scores such as CHA₂DS₂-VASc, and cross-tabulated it directly against observed POAF status in the full cohort (n=408). Observed POAF incidence increased monotonically across risk strata: 15.9% (37/232) with neither risk factor, 24.8% (29/117) with electrolyte imbalance alone, 42.1% (16/38) with preoperative AF alone, and 85.7% (18/21) with both factors present — supporting the face and construct validity of the proposed framework. The highest-risk stratum, while striking, comprised only 21 patients (including just 3 non-POAF), yielding a wide, imprecise confidence interval that warrants cautious interpretation pending validation in a larger cohort. Table 7 shows the clinical performance of the proposed score at candidate cutoffs.

Table 7. Clinical performance of the proposed score at candidate cutoffs (n=408)

Cutoff	Sensitivity	Specificity	PPV	NPV
Score ≥ 1 (electrolyte imbalance)	63.0%	63.3%	35.8%	84.1%
Score ≥ 3 (AF present)	34.0%	91.9%	57.6%	81.1%
Score =4 (both present)	18.0%	99.0%	85.7%	78.8%

Sensitivity/specificity values exactly match the ROC-derived coordinates in Table 5, confirming internal consistency between the modeled probability approach and the directly observed risk-score approach.

Table 8. POAF incidence in selected Asian and international cohorts

Study (Region)	Population	n	POAF Incidence	Key Predictors
Present study (Thailand)	Valve/CABG, multicenter	408	24.5%	Preoperative AF, electrolyte imbalance
Wang et al., Singapore ¹⁴	CABG/valve, multiethnic	2,168	17.3%	Age ≥ 65 , prior AF, inotropes, CPB >120 min, ethnicity
Hsu et al., Taiwan ¹⁵	Open-heart, single center	8,374	Not directly comparable*	POAF associated with future AF/HF/mortality
Perezgrovas-Olaria et al., meta-analysis ²	Mixed regions, 59 studies	197,774	15–40% (range)	Method-dependent

**Reported long-term outcomes rather than a directly comparable incidence figure.*

Discussion

This multicenter study found a 24.5% incidence of POAF among Thai cardiac surgery patients. Preoperative AF and electrolyte imbalance were independent predictors, and patients with POAF had significantly longer ventilation time, ICU stay, and hospital stay.

Regional and Comparative Context

Our incidence (24.5%) falls within the international range (15–40%)², and aligns with other Asian cohorts (Table 8). The Singaporean model (17.3% incidence, AUC 0.704) found clinical predictors broadly similar to those in Western data but noted ethnicity as an independent modifier¹⁴ – suggesting that population-specific calibration of prediction tools may be valuable across Asian subpopulations, including Thailand. Notably, a Thai single-center study quantified the substantial economic burden of POAF within the same healthcare system, reporting attributable costs of approximately 48,000–72,000 Thai Baht (roughly US\$1,600–2,400) per patient, depending on surgery type⁸, reinforcing that the clinical findings of the

present study carry direct, locally relevant economic implications for Thai cardiac surgical services, in addition to their patient-level clinical significance.

Our combined two-factor model's AUC of 0.673 (95% CI 0.607–0.739) indicates modest discriminative ability, somewhat lower than the AUC of 0.704 reported for the more comprehensive multivariable Singaporean model, which incorporated five predictors rather than two¹⁴. This suggests that although preoperative AF and electrolyte imbalance are the strongest independent predictors in our dataset, these two factors alone explain only part of POAF risk, and adding variables (age, left atrial size, intraoperative factors) would likely improve predictive performance in future model iterations.

Interpretation of Key Predictors

Preoperative AF was the strongest predictor (OR 5.364), consistent with findings from Singapore (OR 3.65)¹⁴ and the broader literature^{3,9}. This likely reflects underlying atrial remodeling that predisposes to recurrence under surgical stress⁹ – supporting more vigilant rhythm monitoring and consideration of prophylaxis in this subgroup¹⁰.

Electrolyte imbalance (OR 1.987) is mechanistically linked to altered atrial myocyte excitability/refractoriness^{9,11}. Interestingly, hypokalemia – the predominant electrolyte abnormality – was not independently associated with POAF (OR = 1.457, 95% CI: 0.880–2.412, $p = 0.142$), despite the composite variable being significant. Other individual electrolyte abnormalities occurred too infrequently (each $n < 10$) to allow separate meaningful analysis, methodologically justifying the composite approach. This pattern suggests the composite variable's significance may reflect the cumulative burden of concurrent or fluctuating multi-ion disturbances rather than the effect of hypokalemia alone – consistent with the principle that combined electrolyte derangements are more arrhythmogenic than an isolated abnormality¹¹. Larger cohorts are needed to isolate the independent contribution of hyponatremia, hypocalcemia, and hypomagnesemia. Unlike preoperative AF, electrolyte status remains potentially modifiable: proactive perioperative correction protocols represent a low-cost, implementable intervention meriting prospective evaluation, building on existing meta-analytic evidence that intravenous magnesium supplementation modestly but significantly reduces POAF incidence in the broader cardiac surgery population¹³.

The Proposed Risk Score

The observed POAF incidence increased monotonically from 15.9% to 85.7% across the four risk strata, closely mirroring the discrimination boundaries identified in the ROC analysis (Tables 5 and 7) and supporting the proposed simplified framework. A score ≥ 3 (preoperative AF present) identified a high-specificity threshold (91.9% specificity, PPV 57.6%) suitable for flagging patients who warrant closer perioperative rhythm monitoring, while a lower threshold of score ≥ 1 (electrolyte imbalance) offered higher sensitivity (63.0%) at the cost of specificity, potentially useful as a broader "consider electrolyte optimization" screening trigger. The highest-risk stratum (both factors present, observed incidence 85.7%) is clinically striking but based on only 21 patients; this estimate carries substantial statistical

uncertainty and requires confirmation in a larger, ideally prospective, cohort before guiding individual patient counseling or intervention decisions.

Unexpected Findings: Creatinine and Platelet Count

POAF patients had lower creatinine (1.1 ± 0.5 vs. 1.4 ± 1.4 , $p = 0.023$) than non-POAF patients — contrary to some prior reports linking renal dysfunction to POAF — though this difference did not persist in multivariate analysis. Possible explanations: (1) reverse causality or confounding by indication; (2) confounding by frailty (elevated-creatinine patients managed more conservatively); (3) a statistical artifact from outlier-driven variance. Similarly, POAF patients had lower platelet counts (227.0 ± 69.7 vs. $247.3 \pm 85.3 \times 10^3$, $p = 0.035$), both within the normal range and not independently predictive — possibly reflecting hemodilution, a marker of a more complex perioperative course, or statistical noise. We recommend future prospective studies with serial measurements to clarify these associations rather than inferring causality here.

Clinical Consequences of POAF

Consistent with prior reports^{3,4}, patients who developed POAF in our cohort had significantly longer mechanical ventilation, ICU stays, and hospital stays. These findings mirror large registry data: in a U.S. multicenter analysis of nearly 50,000 cardiac surgery patients, POAF was independently associated with a twofold increase in risk-adjusted mortality, 48 additional ICU hours, 3 additional hospital days, and US\$3,000–9,000 in increased hospital costs per patient⁷. In Thai healthcare settings, POAF has similarly been shown to substantially increase attributable hospital costs⁸, suggesting that our findings are not merely of academic interest but carry direct implications for local resource planning and the cost-effectiveness of prevention strategies. Beyond the index admission, long-term follow-up data indicate that POAF is associated with an elevated risk of recurrent arrhythmia, heart failure, and mortality that persists for years after surgery^{4,15}. Although the association has been debated, several large cohort studies and a post hoc analysis of a major randomized trial have found POAF independently associated with increased long-term stroke risk after isolated CABG^{5,6}, prompting current guideline statements to suggest that long-term oral anticoagulation "may be considered" in appropriately selected patients with POAF and elevated baseline stroke risk. Collectively, these data reinforce the clinical importance of early identification and, where possible, prevention of POAF.

Strengths

The principal strength is the multicenter design across two academic university hospitals and a regional/community hospital, improving generalizability compared with single-center studies. The enrolled sample ($n = 408$) exceeded the pre-specified minimum ($n = 275$), and all key variables had complete data. The combined-model ROC analysis, hypokalemia subgroup analysis, and direct cross-tabulation of observed incidence by risk score — which showed exact internal consistency with the modeled probability approach — add methodological rigor and clinical interpretability.

Limitations

(1) Retrospective design carries a risk of selection bias; (2) the 72-hour POAF window may underestimate the true incidence; (3) unmeasured variables (left atrial size, LV hypertrophy, beta-blocker/antiarrhythmic use, inflammatory markers) may explain why previously reported factors (age, prolonged CPB)¹⁴ were not significant here; (4) electrolyte imbalance could not be stratified by individual ion beyond hypokalemia due to small cell sizes ($n < 10$); (5) findings from three Thai centers may not generalize to other Southeast Asian settings; (6) the proposed risk framework, while showing a clear observed-incidence gradient, remains internally derived and hypothesis-generating, pending external validation; (7) the highest-risk stratum (score = 4) comprised only 21 patients, of whom just 3 did not develop POAF — the resulting risk estimate, while striking, has a wide confidence interval and should not be treated as precise; (8) the combined model's modest AUC (0.673) indicates that unmeasured factors likely contribute substantially to POAF risk beyond the two variables captured here; (9) this study examined only in-hospital outcomes and did not assess longer-term stroke, arrhythmia recurrence, or mortality, which prior literature suggests may also be significantly affected by POAF^{5,6,15}.

Future Directions

We propose: (1) prospective external validation of the 4-tier risk framework in an independent cohort, with formal calibration statistics; (2) a trial of protocolized perioperative electrolyte correction (particularly magnesium), building on existing perioperative arrhythmia management principles and meta-analytic evidence on prophylaxis^{10,12,13}; (3) larger, prospectively designed multicenter studies powered to isolate the independent contribution of individual electrolyte abnormalities beyond hypokalemia; (4) incorporation of additional predictors (age, left atrial size, echocardiographic parameters) to improve model discrimination beyond the current AUC of 0.673, potentially informed by existing risk-modeling approaches in this population^{14,17}; and (5) longer-term follow-up of this cohort to assess stroke, arrhythmia recurrence, and mortality, given emerging evidence that POAF's clinical impact extends well beyond the index hospitalization^{5,6}.

Conclusions

POAF incidence after cardiac surgery in this Thai multicenter cohort was 24.5%. Preoperative AF and electrolyte imbalance were independent risk factors and were associated with significantly longer ventilation time, ICU stay, and hospital stay. Electrolyte imbalance is modifiable and can be addressed proactively to reduce POAF. A simple additive risk score based on these two factors showed a clear, monotonic gradient in observed POAF incidence (15.9% to 85.7%), and the combined model demonstrated modest discrimination (AUC 0.673). Hypokalemia alone was not independently predictive, suggesting that the cumulative burden of electrolyte disturbance — rather than any single ion abnormality — may underlie this association. These findings may support a simple, low-cost preoperative screening strategy, pending prospective external validation.

Declarations

Competing interests

The authors declare no competing interests.

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Author Contribution

Conception and design: SS, ST, YJ, and TS. Data collection: ST, SS, and YJ. Data analysis and interpretation: ST, SS, and TS. Writing the manuscript: ST, SS, and TS. All authors read and approved the final version of the manuscript.

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None.

Data Availability

The datasets of the current study are available from the corresponding author on reasonable request.

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Figures

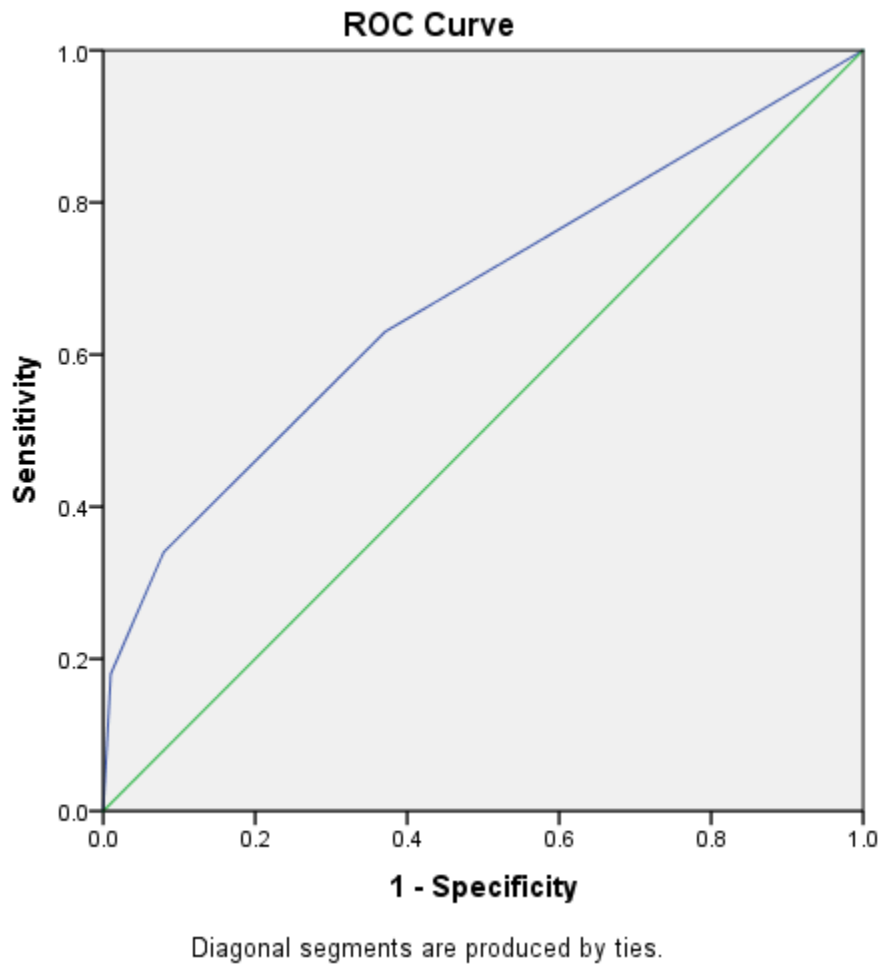


Figure 1

ROC curve of the combined multivariate model (preoperative AF + electrolyte imbalance) demonstrated an area under the ROC curve (AUC) of 0.673 (SE 0.034, 95% CI 0.607–0.739, $p < 0.001$) for predicting POAF.