Postoperative Atrial Fibrillation Following Non-Cardiac Surgery: The Impact of Medical History and Surgical Type

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ABSTRACT **Background:** Postoperative atrial fibrillation (POAF) is well recognized after cardiac surgery; however, its incidence and clinical course following non-cardiac surgery (NCS) remain unclear.

Objectives: To evaluate the association between POAF after NCS, patient co-morbidities, and type of surgery.

Methods: In this retrospective cohort study, patients who underwent NCS at a private hospital network between 2016 and 2023 were included. Patients with a history of atrial fibrillation (AF) were excluded. Patients who developed POAF within 24-48 hours were compared with those who did not. To address baseline differences, propensity score matching (1:10) and inverse probability weighting combined with Firth's penalized logistic regression were applied. Odds ratios with 95% confidence intervals were calculated.

Results: POAF developed in 174 patients within 24–48 hours postoperatively, compared with 391,329 controls. Older age, ischemic heart disease, diabetes, and prior stroke were associated with increased odds of POAF, although significance diminished after multivariable adjustment. Weighted regression confirmed these findings with narrower confidence intervals. Higher POAF risk was observed after laparoscopic pancreatectomy, hepatectomy, rectopexy, synovectomy, and gastrectomy. Total knee replacement was the most common procedure among POAF cases, representing 22% of cases and a fourfold increased risk.

Conclusions: Advanced age and cardiovascular co-morbidities were associated with increased POAF risk after NCS, although attenuated after adjustment. Consistent findings across statistical models support the robustness of the results. Targeted monitoring in high-risk patients may improve postoperative outcomes.

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KEY WORDS: atrial fibrillation, cardiovascular risk, co-morbidities, non-cardiac surgery (NCS), postoperative atrial fibrillation

Postoperative atrial fibrillation (POAF) is defined as new-onset atrial fibrillation (AF) occurring in the immediate postoperative period. Its incidence varies widely, affecting 30–50% of patients undergoing cardiac surgery [1,2] and 5–30% of those undergoing non-cardiac surgery (NCS), with a peak incidence occurring 2–4 days postoperatively [3-5]. In most cases, POAF is a self-limited arrhythmia. However, it is a significant risk factor for complications such as stroke, heart failure, myocardial infarction (MI), and death [5-8]. In addition, POAF is associated with other postoperative complications, including prolonged hospital stay, hemodynamic instability, infections, renal dysfunction, bleeding, increased in-hospital mortality, and higher healthcare costs [1,9,10]. Intra- and postoperative changes, specific AF triggers (including perioperative complications), and pre-existing AF-related risk factors and co-morbidities increase susceptibility to POAF [11,12]. The development of POAF is multifactorial, with the inflammatory response being the most significant contributor. Other contributing factors include hypovolemia, hypotension, anemia, pain, trauma, and sepsis [13]. POAF is particularly common following cardiac surgery, with patients experiencing a four- to five-fold increased risk of AF recurrence within 5 years post-surgery [14]. However, less is known about its incidence and natural progression after NCS [15]. Hypertension, advanced age, obesity, prior ischemic heart disease, obstructive sleep apnea, and male sex have been identified as dominant risk factors for POAF in the context of NCS [13].

We investigated the association between the occurrence of POAF within 24–48 hours after NCS and various chronic co-morbidities. In addition, we examined the relationship between POAF and the types of surgeries performed at a private referral hospital network.

PATIENTS AND METHODS

STUDY POPULATION

In this retrospective study, we analyzed data from patients who underwent NCS at Assuta Medical Centers between 2016 and 2023 and subsequently developed POAF. Assuta Medical Centers are a network of private hospitals in Israel performing over 40,000 surgeries annually. Demographic data, co-morbidities, medications, surgical details, postoperative outcomes, discharge information, and follow-up data were extracted from institutional medical records and imaging databases. The study was approved by the institutional Helsinki review board.

STUDY PROTOCOL

The cohort comprised all adult patients diagnosed with POAF by electrocardiogram documentation or electrocardiogram telemetry following NCS during the study period. These patients were compared to a control group of individuals who underwent NCS within the same timeframe but did not develop POAF.

Table 1. Baseline characteristics

	With POAF (N=174)	Without POAF (N=391,329)	*P*-value
Patient characteristics			
Age in years	69.9 ± 9.2	42.6 ± 23.15	0.01
Sex-male	60.34%	52.46%	0.22
Smoker	2.87%	0.57%	< 0.01
Background diseases			
Hypercholesterolemia	13.22%	4%	< 0.01
Hypothyroidism	5.17%	2.02%	< 0.01
Obesity	8.62%	1.80%	< 0.01
CVA/TIA	2.30%	0.58%	< 0.05
Diabetes	22.41%	4.30%	< 0.01
Hypertension	40.22%	0.00%	< 0.01
Surgeries			
Laparoscopic cholecystectomy	5.17%	4.20%	0.76
Umbilical hernia repair	0.57 %	2.53%	< 0.1
TKR	21.84%	2.59%	< 0.01
TURP	6.90%	1.92%	< 0.01

CVA/TIA = cerebrovascular accident/transient ischemic attack, POAF = postoperative atrial fibrillation, TKR = total knee replacement surgery, TURP = transurethral resection of the prostate

INCLUSION AND EXCLUSION CRITERIA

Patients included adults older than 18 years who had been diagnosed with POAF between 2016 and 2023. Patients with a documented history of atrial fibrillation (paroxysmal, persistent, or permanent) determined by prior medical records or medication use were excluded. We evaluated associations between patient co-morbidities and the development of POAF, as well as the relationship between types of NCS and POAF occurrence.

STATISTICS

Categorical variables were reported as percentages, and continuous variables as medians and means ± standard deviations. Continuous variables were compared using independent-samples *t*-tests when normally distributed and Mann–Whitney tests otherwise. A two-sided P-value < 0.05 was considered statistically significant. Statistical analyses were performed using R Statistical Software, version 1.03.2023 (R Foundation for Statistical Computing, Vienna, Austria).

Univariate analyses used chi-square or Fisher's exact tests to examine associations between POAF (within 24–48 hours post-surgery) and chronic diseases, co-morbidities, and surgery type, with odds ratios calculated for effect size. To adjust for baseline differences between POAF and control groups, two approaches were applied: propensity score matching (1:10 nearest-neighbor matching on age, sex, and co-morbidities), and inverse probability weighting) using propensity scores combined with Firth's penalized logistic regression to address rare-event bias. Independent predictors of POAF were identified from these models. Model performance and covariate balance were evaluated using standardized mean differences and Love plots.

RESULTS

BASELINE CHARACTERISTICS

The study included 227 consecutive patients who underwent NCS between 2016 and 2023 and developed AF within 24–48 hours post-surgery. We excluded 53 patients with a history of AF (determined by medical history or prior use of anticoagulation therapy) or with non-AF arrhythmia. This cohort of 174 patients was compared to a control group of 391,329 patients who underwent NCS during the same period and did not develop POAF. Among the 174 patients included in the study, the mean age was 69 ± 9 years, 60.3% were male, 22.4% had diabetes, and 40% had hypertension [Table 1]. Compared to patients without POAF, those who developed POAF were older and had significantly more co-morbidities, including higher rates of diabetes, hypertension, hyperlipidemia, and obesity as well as a past stroke [Table 1].

Table 2. Risk of postoperative atrial fibrillation according to type of surgery

Surgery type	Odds ratio	95% confidence interval	*P*-value
TKR	4.08	7.12–15.15	< 0.01
Gastrectomy	33.94	4.03–126.77	< 0.01
TURP	3.56	1.41–7.51	< 0.01
Groin hernia repair	2.95	1.25–5.97	< 0.01
Large/small intestine surgery	16.97	8.57–30.55	< 0.01
Hepatectomy	86.99	2.10–542.92	< 0.01
Laparoscopic pancreatectomy	113.09	2.71–706.46	< 0.01
Laparoscopic cholecystectomy	0.76	0.29–1.81	0.84
Bariatric surgery	1.28	0.57–2.50	0.43
Knee arthroscopy	0	0.00–2.40	0.37
Shoulder arthroscopy	0.33	0.00–1.91	0.40
Hydrocele surgery	0.88	0.02–5.00	< 0.01
Abdominal wall hernia repair	0	0.00–11.09	< 0.01
Anal fissure surgery	0.66	0.13–1.98	0.64
Lumpectomy	0.27	0.00–1.53	0.26
Proctectomy	15.8	0.39–90.90	< 0.1
Mastectomy	1.03	0.21–3.09	< 0.01
Appendectomy	10.51	0.26–59.95	0.09
Exploratory laparotomy	0	0.00–112.63	< 0.01
Laparotomy	13.38	0.33–76.64	0.07
Total hip replacement	4.08	1.99–7.50	< 0.01
Paraesophageal hernia repair	16	1.91–59.28	< 0.01
Open prostatectomy	17.76	7.01–37.60	< 0.01
Nephrectomy	6.4	1.72–16.73	< 0.01
Synovectomy	42.67	1.05–252.78	< 0.01
Rectopexy	53.86	1.32–321.88	< 0.01
Radical Prostatectomy	7.89	2.85–17.58	< 0.01
Ureteroscopy	0.69	0.08–2.56	0.83

TKR = total knee replacement surgery, TURP = transurethral resection of the prostate

POAF ACCORDING TO TYPE OF NCS

General surgeries (i.e., non-orthopedics, non-urologic, non-gynecologic surgeries that were either laparoscopic or open) accounted for approximately 31% of all procedures, with an AF incidence of only 0.02%. Similarly, gynecological and neonatal surgeries also had low AF rates, at approximately 0.01%. Among all POAF cases, total knee replacement surgery (TKR) accounted for the largest proportion (22%), followed by procedures involving large abdominal incisions (8%) and bariatric surgery (approximately 6%). Odds ratios were calculated to quantify the strength of the associations between the type of surgery and the likelihood of developing POAF [Table 2]. Laparoscopic pancreatectomy, hepatectomy, rectopexy, synovectomy, gastrectomy, open prostatectomy, and intestine surgeries had the highest risk for developing POAF. However, since TKR was the most prevalent surgery that was associated with POAF [Table 1], it is probably the most significant one. Conversely, no significant associations were observed for procedures such as laparoscopic cholecystectomy, bariatric surgery, knee arthroscopy, shoulder arthroscopy, hydrocele surgery, abdominal wall hernia repair, anal fissure surgery, lumpectomy, proctectomy, mastectomy, appendectomy, exploratory laparotomy, or laparotomy. The relationship between umbilical hernia repair and POAF was borderline significant, indicating a potential but unclear link (P = 0.059 in chi-square test, P = 0.025 in Fisher's exact test).

AGE DISTRIBUTION IN PATIENTS WITH POAF AND NCS

Approximately 46% of these patients were aged 70–80 years, around 11% were aged 50–60 years, and fewer than 2% were aged 30–40 years. A two-sample t-test was performed to assess the relationship between the occurrence of POAF and patient age. The analysis revealed a significant difference in mean age between patients who developed POAF and those who did not (t = -38.93, df = 173.97, P < 0.01). Specifically, the mean age of patients without POAF was 42.63 years, compared to 69.85 years for those with POAF [Table 1]. The 95% confidence interval (95%CI) for the difference in means ranged from -28.59 to -25.83 years, highlighting a substantially and statistically significant older age among patients who developed POAF.

CO-MORBIDITIES IN PATIENTS WITH POAF AND NCS

Figure 1 illustrates the prevalence of underlying conditions among patients who experienced POAF. Notably, 22.4% of these patients had diabetes, 40% had hypertension, and only 2.3% had a history of cerebrovascular accident (CVA) or transient ischemic attack (TIA).

A significant association was identified between several chronic diseases and the incidence of AF. Ischemic heart disease was linked to a 4.86-fold higher risk of POAF ($P < 0.05$). Diabetes was associated with a 3.56-fold increased risk ($P < 0.01$), and hypercholesterolemia increased the risk by 3.11 times ($P < 0.01$). Similarly, hypothyroidism and a history of CVA/TIA were associated with increased risks, with odds ratios (OR) of 2.95 ($P < 0.01$) and 3.00 ($P < 0.01$), respectively. However, no significant associations were observed for hypertension or obesity.

MULTIVARIABLE ANALYSES

To control for confounding and baseline imbalances, two complementary multivariable models were applied [Table 3]. In the propensity-score–matched cohort (1:10 ratio), hypertension remained independently associated with POAF (OR = 10.57, 95%CI 1.83–63.53, $P = 0.006$), while all other co-morbidities were not significant after adjustment. In contrast, the weighted logistic regression model with Firth correction, which incorporated all observations and corrected for rare-event bias identified several significant predictors, including age (OR = 1.04, $P < 0.001$), diabetes (OR = 0.87, $P < 0.001$), ischemic heart disease (OR = 0.50, $P < 0.001$), hypercholesterolemia (OR = 1.45, $P < 0.001$), hypothyroidism (OR = 0.26, $P < 0.001$), obesity (OR = 3.10, $P < 0.001$), and previous stroke/TIA (OR = 0.002, $P < 0.001$) [Table 3].

Although the two models differed in statistical significance, the direction of associations was largely consistent across methods, suggesting robustness rather than contradiction. The propensity-matched model provided more conservative estimates and identified hypertension as a potential independent predictor, while the weighted model increased statistical power and precision, yielding broader significance. Together, these complementary analyses support the stability and reliability of the findings.

Figure 1. Prevalence of co-morbidities among patients who developed POAF

POAF = postoperative atrial fibrillation, IHD = ischemic heart disease, CVA/TIA = cerebrovascular accident/transient ischemic attack

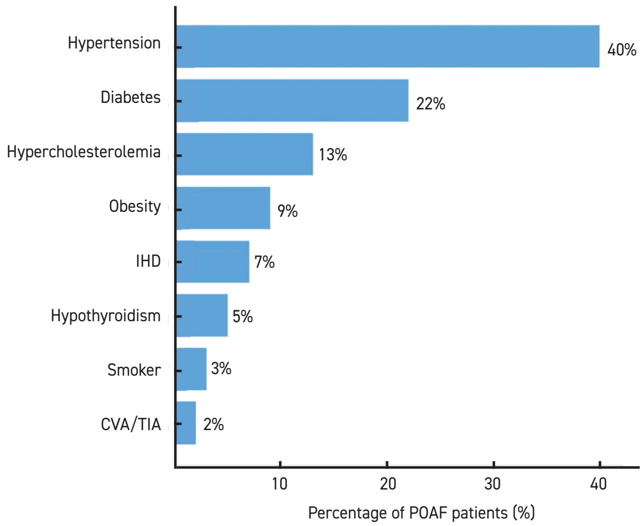

Table 3. Multivariable analyses: propensity-matched and weighted logistic regression models

Variable	Propensity-matched (1:10): OR (95%CI)	*P*-value (matched)	Weighted logistic regression (Firth): OR (95%CI)	*P*-value (weighted)
(Intercept)	0.117 (0.025–0.484)	0.004	0.013 (0–0.201)	0.002
Age	0.997 (0.977–1.018)	0.747	1.043 (1.043–1.044)	0.00
Sex (Male)	1.064 (0.698–1.644)	0.776	5.578 (0.36–805.575)	0.233
Diabetes	0.971 (0.488–1.805)	0.93	0.866 (0.845–0.887)	0.00
High blood pressure	10.569 (1.827–63.533)	0.006	1.251 (0.853–1.858)	0.254
Ischemic heart disease	1.864 (0.28–7.367)	0.432	0.495 (0.454–0.54)	0.00
Hypercholesterolemia	1.178 (0.548–2.316)	0.653	1.477 (1.414–1.481)	0.00
Hypothyroid	0.999 (0.155–3.614)	0.999	0.26 (0.247–0.272)	0.00
Obesity	1.643 (0.612–3.908)	0.288	3.097 (2.998–3.2)	0.00
CVA/TIA	0.457 (0.023–2.79)	0.488	0.002 (0.001–0.003)	0.00

Differences in *P*-values between models reflect variation in weighting and estimation methods rather than inconsistent effects
95%CI = 95% confidence interval, OR = odds ratio, CVA/TIA = cerebrovascular accident/transient ischemic attack

DISCUSSION

AF is the most common arrhythmia encountered in clinical practice. Patients are particularly susceptible to developing AF in the immediate postoperative period due to transient surgery-related physiological factors, including inflammation, oxidative stress, and heightened sympathetic activity. Although AF frequently occurs shortly after surgery and often resolves spontaneously as the patient's condition stabilizes, the incidence observed in previously reported rates have ranged from 5% to 30% [15].

Until recently, POAF following NCS was considered a relatively benign complication, as it is often asymptomatic and self-limiting. However, recent research has highlighted its significance due to its impact on post-surgical hemodynamic stability, prolonged hospitalization, increased healthcare costs, and elevated risks of stroke and other complications [13,16].

Our study results provide valuable insights into the risk factors for developing early POAF following NCS at a large private referral center in recent years. Consistent with previous studies [13], older age and cardiovascular co-morbidities were associated with higher odds of developing POAF, although their independent effects varied depending on the analytic method used. In the propensity-score–matched model, hypertension emerged as the only independent predictor of POAF, while in the weighted logistic regression with Firth correction, several additional co-morbidities including age, ischemic heart disease, diabetes, hypercholesterolemia, hypothyroidism, obesity, and prior cerebrovascular disease reached statistical significance. Despite these differences, the direction of associations remained consistent across models, indicating robustness rather than contradiction.

These discrepancies likely reflect methodological differences between the two models: the matched analysis prioritizes strict covariate balance but is limited by smaller sample size and lower statistical power, whereas the weighted model retains all observations, increasing power and sensitivity but potentially overestimating marginal effects. Therefore, the matched results were considered the primary findings, with the weighted model serving as a sensitivity analysis confirming the stability of the observed trends.

Our findings indicate that certain surgical procedures such as TKR, gastrectomy, and hepatectomy were associated with a substantially increased risk of POAF, whereas procedures like laparoscopic cholecystectomy and bariatric surgery did not demonstrate a similar effect. Laparoscopic pancreatectomy, hepatectomy, rectopexy, and synovectomy were also linked to a higher likelihood of developing POAF. However, these operations represented relatively low-volume procedures in our cohort, which may limit the precision of the estimated risk. The seemingly high POAF incidence associated with TKR in our study reflects its proportion among all POAF cases rather than an incidence calculated based on the total number of TKR procedures performed. This distinction is essential to avoid overestimating the true procedure-specific risk.

These findings align with other studies demonstrating that the surgical approach can influence POAF, with open surgery showing higher incidence rates than laparoscopic procedures [17]. In addition, prolonged mechanical ventilation, longer surgical durations, and the use of general anesthesia are known to increase the incidence of POAF [18,19].

To the best of our knowledge, this is the first study to explore the association between the type of NCS and the risk of developing POAF. While multiple strategies to prevent POAF with pre-treatment or acute drug treatment have been described, there is lack of evidence from large randomized controlled trials (RCTs). The new AF guidelines [18] recommend treating POAF according to the AF-CARE pathway, like first-diagnosed AF; however, RCTs are continuing to be conducted.

Our study has several limitations, including its small sample size, retrospective design, heterogeneity of surgical types, differences in perioperative monitoring, and reliance on available medical records. In addition, the lack of complete electrocardiogram records or electrocardiogram telemetry for all patients, which under detects transient or asymptomatic POAF events, the lack of documented regular medication (such as beta-blockers and amiodarone), and the use of a single treatment for POAF (intravenous amiodarone) may have introduced selection and information bias. In addition, although the definition of POAF in the ESC guidelines relate to a larger postoperative window, we captured only a narrower slice of up to 7 days postoperative, and mainly up to 48 hours, due to the setting of data-collection at this hospital. Furthermore, the imbalance between groups necessitated the use of advanced statistical methods such as propensity matching and inverse probability weighting. While these techniques improved validity, they may also have introduced model-dependent variability. Thus, our findings require validation in matched-controlled or prospective datasets.

Our findings underscore the importance of incorporating patient history and the type of surgical procedure when evaluating the risk of POAF. Enhanced monitoring and targeted preventive strategies should be reserved for individuals at higher risk to reduce the likelihood of adverse outcomes. Based on our results, extended electrocardiogram surveillance such as the use of a 30-day external loop recorder may be appropriate for patients with specific risk factors, including ischemic heart disease, a history of stroke or TIA, diabetes mellitus, advanced age, and those undergoing procedures such as TKR or major abdominal surgery

CONCLUSIONS

Older age, hypertension, and other vascular co-morbidities were associated with an increased likelihood of developing POAF following NCS, although these associations varied depending on the analytical approach. In the propensity-matched model, hypertension emerged as a potential independent predictor, whereas the weighted model with greater statistical power revealed broader but method-dependent significance across several co-morbidities. Despite these differences, both approaches demonstrated consistent directions of association, reinforcing the robustness of the findings. Enhanced perioperative monitoring and proactive management of patients with cardiovascular risk factors may help reduce POAF incidence and improve postoperative outcomes.

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**I should dearly love that the world should be ever so little better for my presence.
Even on this small stage we have our two sides, and something might be done by throwing all one's weight on the scale of breadth, tolerance, charity, temperance, peace, and kindliness to man and beast.
We can't all strike very big blows, and even the little ones count for something.**

Arthur Conan Doyle (1859–1930), British writer and medical doctor, created the character Sherlock Holmes