21st Century Publisher

21 ST CENTURY CARDIOLOGY

21st Century CARDIOLOGY

Editorial

Open Access

Seven Things We Need to Know about Postoperative Atrial Fibrillation: Editorial

Joseph V. Pergolizzi Jr.[1]*, Jo Ann LeQuang[1] and Peter Magnusson[2,3]

[1]NEMA Research Inc., Naples, Florida, USA

[2]Centre for Research and Development, Region Gävleborg/Uppsala University, Gävle, Sweden

[3]Department of Medicine, Cardiology Research Unit, Karolinska Institutet, Stockholm, Sweden

***Corresponding Author:** Joseph V. Pergolizzi Jr., NEMA Research Inc., Naples, Florida, USA

Received: 01 September 2021; **Accepted:** 22 November 2021; **Published:** 28 November 2021

Introduction

Atrial fibrillation (AF) remains the most frequently occurring arrhythmia in the world and despite a greater understanding of the arrhythmia, rates of AF are rising sharply, increasing three-fold in the last 50 years [1]. Acute postoperative AF (POAF) occurs in the near postoperative period following both cardiac and noncardiac surgeries. The incidence ranges from 30 to 60% following cardiac surgery, and 5 to 10% following noncardiac surgery, which is not as well studied [2-8]. At times, POAF may be self-limiting and resolve spontaneously with no immediate complications, and, as a result, it is sometimes perceived as a clinically insignificant and transient condition The proportion of POAF cases that resolve spontaneously has not been quantified, but with over 900,000 cardiac surgeries every year in the United States alone, [9] it is plausible that several hundreds of thousands of patients a year experience non-limiting POAF. Noncardiac surgery patients may not be continuously monitored for AF following their surgeries. The result is that the actual incidence of POAF may be underestimated, just as the impact of POAF on the healthcare system may be minimized [10]. POAF is associated with a significantly higher risk of stroke; in one study, stroke risk was 11.1% for POAF patients compared to 1.9% in patients who maintained sinus rhythm [11]. POAF is also associated with greater morbidity, longer hospital stays, and higher mortality [10, 12]. Yet despite its prevalence and associated risks, there is very little information to guide the clinician and some questions that demand answers.

Is there a Clinically Meaningful Difference between POAF following Cardiac Surgery and POAF Following Noncardiac Surgery? And how does this Compare to Nonvalvular AF?

The clinical course of POAF is not well studied in noncardiac surgery patients, [13] and it cannot be said if POAF following noncardiac surgery has different risks or outcomes than POAF after cardiac surgery. Noncardiac patients with POAF have a greater risk of congestive heart failure, myocardial infarction, cardiac arrest, bacterial pneumonia, and longer hospital stays [12]. POAF is associated with a risk of stroke. POAF patients have a 37% higher risk of late stroke and a 37% higher risk of late mortality compared to those without POAF. Interestingly, the risk of late stroke was higher in noncardiac surgery than in cardiac surgery patients [14]. POAF following coronary artery bypass graft (CABG) procedures, the risk for thromboembolism was lower than in patients with nonvalvular AF [15]. In a study of 22,007 noncardiac surgery patients who developed POAF, 5% had thromboembolism within four years [16]. In a study of 675 cardiac surgery patients with POAF matched to 2,025 patients with nonvalvular AF, the long-term risk of thromboembolism was similar in both groups [17].

In a study of 744 cardiac surgery patients, five-year survival was 83% for those with POAF and 93% for those without ($p<0.001$) [18]. POAF in both noncardiac and cardiac surgery patients increased the risk of early and long-term mortality [14].

Of interest is the fact that POAF following noncardiac surgery appears to be associated with more harmful effects than POAF after cardiac surgery [19]. POAF increases the risk of stroke in cardiac surgery patients by about 20%, but it doubles the risk of stroke in noncardiac surgery patients [14]. Lin and colleagues proposed an explanation of this by saying that manipulation of the cardiac tissue may precipitate POAF in cardiac surgery but as the heart heals, these factors no longer affect the heart. The mechanism of POAF following noncardiac surgery has not been adequately studied, but is likely somewhat different than the mechanisms of POAF following cardiac surgery and could involve an interplay of several factors [14, 20, 21].

How Many Patients Develop POAF Following Noncardiac Surgery?

The rate of POAF following noncardiac surgery is not well studied and reported incidences vary widely from 10% to 30% [5, 21].

However, with about 300 million noncardiac surgery patients per year around the world, patients likely to experience POAF following noncardiac surgery represent a considerable population [22]. The rate of POAF appears to vary with the type of surgery and it is higher following noncardiac thoracic than other surgeries [5, 21]. A study of 24,125 patients undergoing noncardiac surgery under general anesthesia found that hip fixation and laparotomy surgeries likewise produce high rates of POAF. POAF occurred at a rate of 10% in noncardiac cancer-surgery patients [23]. It should be noted that this rate may be underestimated because noncardiac patients are not routinely monitored for POAF and those who are monitored may not be continuously monitored. Because noncardiac surgery patients are often not monitored for AF or are monitored, at most, intermittently, POAF may easily go undetected [24]. POAF following noncardiac surgery typically occurs in the first four days after surgery [21].

Are there Long-term Risks with POAF?

Since many cases of POAF are self-limiting without complication or may occur sub-clinically in noncardiac surgery patients, there is a tendency to think of it as a transient or at least temporally sequestered phenomenon. However, POAF following surgery may recur as a more persistent late form of AF long after surgery. Recurrent AF has a significant and little-appreciated association with POAF following noncardiac surgery at one year (31% of POAF vs. 3% of those without POAF, $p<0.001$). It is alarming that 92% of the patients who developed recurrent AF within a year after noncardiac surgery had asymptomatic AF [23].

The risk of POAF transitioning into late or so-called "recurrent" AF is clinically important. In a study of 322,688 patients who underwent major noncardiac surgery under general or local anesthesia, 0.6% developed POAF, but of that population, 16.8% developed recurrent AF [25]. Those with recurrent AF had a significantly greater rate of thromboembolic events and a greater risk of major bleeding events [25]. However, all-cause mortality was not significantly different in those with or without recurrent AF (45.3% vs. 30.5%, $p=0.15$) [25].

A study of 23 CABG patients with POAF used injectable cardiac monitors and found 60.9% experienced recurrent AF (n=14) and persisted for over three months in 10/14 of them. Of the 17 patients followed for a year or more, 8/17 had recurrent AF more than one year after the CABG surgery with the meantime from surgery to the first episode of recurrent AF 143 ± 22.5 days [26]. In a meta-analysis (8 studies, n=1,157) noninvasive monitoring detected POAF in the first four weeks after hospital discharge in 28.3% of cardiac surgery patients and recurrent AF occurred at a rate of 61% to 100% over two years, and 40% to 93% of episodes were asymptomatic [27]. In a study of noncardiac surgery patients, those who developed POAF (0.8%) had a cumulative one-year risk of stroke of 1.5% compared to 0.4% of patients who did not experience POAF. It should be noted that a higher CHA2DS2-VASc score in these patients was associated with an increased one-year cumulative stroke risk.

Is POAF After Noncardiac Surgery a Clinically Meaningful Event?

For noncardiac surgery patients, POAF is associated with a higher risk for stroke, myocardial infarction, and all-cause mortality [28]. Noncardiac surgery patients who develop POAF also have a greater risk of congestive heart failure, myocardial infarction, cardiac arrest, bacterial pneumonia [29] and longer hospital stays 12 It has been speculated that POAF after noncardiac surgery has a different etiology than POAF after cardiac surgery, which may be the reason for these differences [8,21].

Nor is it known if noncardiac surgery patients who develop POAF have an elevated risk for thromboembolic events. A retrospective database study found noncardiac surgery patients developed POAF at a rate of 0.4% and of these patients 3830 were matched with 15,320 patients with nonsurgical nonvalvular AF [15]. Long-term thromboembolic events were similar in the POAF and the nonvalvular AF patients (31.7 vs. 29.9 events per 1000 person-years) and anticoagulation therapy in POAF patients was associated with a significantly lower risk of thromboembolism [15].

Noncardiac surgery patients with POAF have an increased 30-day and one-year risk of stroke than cardiac surgery patients with POAF [14]. Overall, POAF patients had a 62% greater chance of early stroke and 44% greater change of early death compared to those without POAF [14]. While POAF in noncardiac surgery patients may go undetected, it can be a clinically important event.

What are the Costs Associated with POAF?

POAF following CABG surgery was shown to significantly prolong hospital stay compared to patients who did not develop POAF (15,1 ± 9,0 versus 10.0 ± 4,6 days, respectively) [30], and such extended hospitalizations are associated with higher costs. In a retrospective database study of CABG patients with and without acute POAF (n=549 and 1,547, respectively), those with POAF had discharge costs $13,993 higher than those without POAF and 3.9 days longer length of stay in the hospital. At one year post-discharge, POAF patients were at a significantly higher risk for mortality ($p<0.01$) and had a total of $15,593 higher costs, most of which was due to the prolonged hospitalization for the surgery [31]. Extrapolated out to the national level and based on the AF prevalence by age and sex, the national incremental costs of AF in the United States range from $6 to $26 billion [32]. The direct medical costs in an AF patient are about 73% greater than the costs in a matched control subject without AF. The primary incremental cost associated with AF is hospitalization [32]. Since the global incidence of AF is rising [1], these costs may be expected to increase markedly.

What are the Risk Factors for POAF?

Risk factors for POAF may be specific to the patient or they may relate to the type of surgery. In general, the main risk factors for POAF after cardiac or noncardiac surgery include older age, male sex, a history of congestive heart failure, and hypertension. Among noncardiac surgery patients only, lung illness, and brain natriuretic peptide (BNP) are also predictive factors [15,21,33,34]. The type of surgery plays a role; cardiac surgery has a higher incidence of POAF than noncardiac surgery.

A POAF risk-stratification algorithm was developed awarding one point for the male sex, one point for heart rate ≥ 72 bpm, three points for those between the ages of 55 and 74, and four points for those 75 and older. In a study of 856 patients, 17.2% developed POAF but none of them had a score of 0 using this algorithm; of those who scores 6 on this metric, 35.3% developed POAF [35]. A somewhat different risk-stratification algorithm for postoperative complications in general following cardiac surgery assigns one point each for age between 60 and 69, history of the chronic obstructive pulmonary disorder (COPD), estimated glomerular filtration rate <15 mL/min/1.73 m2 or dialysis, emergency surgery, preoperative need for an intra-aortic balloon pump, left-ventricular ejection fraction <30%, and undergoing valvular surgery. Furthermore, one extra point is assigned for each decade above 70. Patients who scored 3 or higher on this metric had a higher rate of complications, greater mortality, higher rate of stroke, and more need for renal replacement therapy [36].

The CHA2DS2-VASc scoring tool was designed to assess AF patients for their risk for ischemic stroke. A study of 2385 patients used this metric to evaluate the risk of new-onset POAF in cardiac surgery patients [37]. In this cohort, 15.9% developed POAF and the mean CHA2DS2-VASc score for those with POAF was 3.6±1.7 compared to 2.8±1.7 for those without POAF (p<0.0001). Multivariate analysis found that as the score increased from 0 to 9, the risk of POAF increased from 8.2 to 42.3%. Thus, every incremental CHA2DS2-VASc point increased the risk of POAF [37]. A study of 277 cardiac surgery patients found that a higher score on the CHA2DS2-VASc instrument was predictive of POAF [38]. A systematic review of 12 studies (n=18,086) found the CHA2DS2-VASc tool was an independent predictor of POAF after cardiac surgery (odds ratio 1.5, 95% CI, 1.3-1.7) with 70% specificity and 72% sensitivity [39]. Valve surgery appears to be associated with a high rate of POAF, which may develop into recurrent AF [21]. In a retrospective study of 10,461 cardiac valve surgery patients, 13% developed POAF within two weeks after and the rate of AF at seven years postoperatively was 9%. Risk factors for POAF in this population were preoperative tricuspid valve regurgitation, mitral valve replacement, and history of cardiac surgery [21].

POAF may also occur following pulmonary resection; in fact, AF is the most common postoperative arrhythmia following lung cancer surgery [40]. In one study, POAF occurred in 5.2% of cancer-related lobectomies and conferred a poorer prognosis than patients who did not have POAF [41]. In this study (n=947 lung cancer patients), poor performance status, COPD, history of paroxysmal AF, and intraoperative blood transfusion emerged in multivariate analysis as POAF predictors [41]. Other risk factors for POAF following pulmonary surgery include male sex, resected lung volume, BNP, and left-ventricular early transmural velocity/mitral annular early diastolic velocity, but none of these independent predictors had a strong predictive value [40].

A meta-analysis of 24 studies reported standardized mean differences between POAF and non-POAF in cardiac surgery patients and found age, left-atrial diameter, left-ventricular ejection fraction, heart failure, chronic obstructive pulmonary disease, hypertension, and history of myocardial infarction to be significant independent predictors of POAF; diabetes was only slightly predictive (1.06, 1.00-1.13) [42]. In a database study of 370,447 surgical patients, 3.0% developed POAF during their stay in the hospital, of whom about two-thirds (67%) had a history of diagnosed AF. Black patients had a significantly lower risk of POAF than other patients (adjusted odds ratio 0.53, 95% CI, 0.48-0.59, p<0.001) [33].

Why do see Racial Differences with POAF?

Following CABG surgery, Black Americans are at significantly lower risk of POAF than Americans of European ancestry (29.3% vs. 18.5%, p=0.001) [43]. In a propensity-adjusted analysis, POAF occurred in 22% of Black patients, 29% in other non-Caucasian patients, and 35% of Caucasian patients (p<0.0001 for Black versus Caucasian). Other studies of CABG patients have confirmed this [44]. Hispanic patients have a similar rate of POAF as Caucasians [45].

There are other racial differences as well. In a study of multiethnic Asian cardiac surgery patients conducted in Singapore (n=2,168), POAF occurred in 17.3% of patients, with most cases occurring in the first 72 hours after the operation. Among the patients, Chinese had a greater risk than Indians (odds ratio 2.09, 95% CI, 1.28-3.41, p=0.003) for developing POAF, and Malayans were at greater risk than Indians (OR 2.43, 95% CI, 1.36-4.05, p=0.002) [46]. Among Asian patients, cardiac surgery patients with POAF had an increased risk for recurrent AF, heart failure, and increased mortality, but not an increased risk for ischemic stroke [47]. Racial and ethnic disparities in POAF suggest that there may be some heritability factors involved in the development of POAF, although more research is needed.

Discussion

POAF is prevalent following cardiac and noncardiac surgery, and POAF is associated with potentially life-threatening complications, yet there are still knowledge gaps in its etiology, epidemiology, and treatment (it goes beyond the scope of this article to describe

treatment strategies). To some extent, the incidence of POAF may not be known, particularly in the context of specific surgeries or specific patient populations. While cardiac surgery patients may be monitored continuously in the perioperative period for cardiac arrhythmias, such continuous monitoring is less frequent among noncardiac surgery patients. POAF, like paroxysmal AF, can be very challenging to get "on the record," as the arrhythmia can start without warning, may not last very long, may be self-limiting, and is often asymptomatic. POAF has the potential to develop into recurrent AF. The advent of injectable cardiac monitors and, to a lesser extent, patient wearables, have expanded our understanding of chronic AF prevalence.

POAF is complicated, because there appears to be clinically important distinctions between POAF after cardiac versus noncardiac surgery. More research is needed. There are also suggestions that POAF in the immediate postsurgical period may be different than POAF that develops in the ensuing days; again, more study is needed.

Our growing appreciation of POAF reveals a few unmet medical needs. There needs to be better but cost-effective ways to monitor surgical patients (even noncardiac surgery patients) for POAF during their hospital recovery times. Furthermore, safe, effective, and cost-effective POAF treatments are needed.

Conclusion

Although POAF in some cases may be self-limiting and asymptomatic, it is a prevalent condition associated with increased costs, considerable morbidity, and mortality. In some cases, POAF may lead to recurrent AF. There are some mistaken notions about POAF, namely that it develops only after cardiac surgery (POAF develops after noncardiac surgeries as well and may have more severe consequences), that it is not a serious problem (it may lead to immediate effects such as myocardial infarction, stroke, or thromboembolic events or develop into recurrent AF), and that the condition is thoroughly elucidated. More research is needed to better understand safe, effective, and cost-effective ways to treat POAF.

References

1. Kornej J, Börschel CS, Benjamin EJ, et al. (2020) Epidemiology of Atrial Fibrillation in the 21st Century. Circ Res 127: 4-20. https://doi.org/10.1161/circresaha.120.316340
2. Koren O, Hakim R, Israeli A, et al. (2020) Postoperative new-onset atrial fibrillation following noncardiac operations: prevalence, complication, and long-term MACE. Cardiol Res Pract 2020: 8156786. https://doi.org/10.1155/2020/8156786
3. Antonelli D, Peres D, Freedberg NA, et al. (2004) Incidence of postdischarge symptomatic paroxysmal atrial fibrillation in patients who underwent coronary artery bypass graft. Pacing Clin Electrophysiol 27: 365-367. https://doi.org/10.1111/j.1540-8159.2004.00443.x
4. Attaran S, Shaw M, Bond L, et al. (2011) Atrial fibrillation postcardiac surgery: a common but a morbid complication. Interactive Cardiovasc and Thorac Surg 12: 772-777. https://doi.org/10.1510/icvts.2010.243782
5. Gialdini G, Nearing K, Bhave PD, et al. (2014) Perioperative atrial fibrillation and the long-term risk of ischemic stroke. Jama 312: 616-622. https://doi.org/10.1001/jama.2014.9143
6. Dave S, Nirgude A, Gujjar P, et al. (2018) Incidence and risk factors for development of atrial fibrillation after cardiac surgery under cardiopulmonary bypass. Indian J Anaesth 62: 887-891. https://doi.org/10.4103/ija.ija_6_18
7. Greenberg JW, Lancaster TS, Schuessler RB, et al. (2017) Postoperative atrial fibrillation following cardiac surgery: a persistent complication. Eur J CardioThorac Surg 52: 665-672. https://doi.org/10.1093/ejcts/ezx039
8. Maesen B, Nijs J, Maessen J, et al. (2012) Post-operative atrial fibrillation: a maze of mechanisms. Europace 14: 159-174. https://dx.doi.org/10.1093/europace/eur208
9. iDataResearch (2021) How many cardiac surgeries are performed each year? New study by iData Research. iDataResearch.com. https://idataresearch.com/over-900000-cardiac-surgeries-performed-every-year-in-the-united-states/
10. January CT, Wann LS, Calkins H, et al. (2019) 2019 AHA/ACC/HRS focused update of the 2014 aha/acc/hrs guideline for the management of patients with atrial fibrillation: a report of the american college of cardiology/american heart association task force on clinical practice guidelines and the heart rhythm society. J Am Coll Cardiol 74: 104-132. https://doi.org/10.1016/j.jacc.2019.01.011
11. Ronsoni RM, Souza AZM, Leiria TLL, et al. (2020) Update on management of postoperative atrial fibrillation after cardiac surgery. Braz J Cardiovasc Surg 35: 206-210. https://dx.doi.org/10.21470/1678-9741-2019-0164
12. Polanczyk CA, Goldman L, Marcantonio ER, et al. (1998) Supraventricular arrhythmia in patients having noncardiac surgery: clinical correlates and effect on length of stay. Ann Intern Med 129: 279-285. https://doi.org/10.7326/0003-4819-129-4-199808150-00003
13. Aguilar M, Nattel S (2019) Postoperative atrial fibrillation after noncardiac surgery: Maybe not so benign after all. Can J Cardiol 35: 1423-1425. https://doi.org/10.1016/j.cjca.2019.08.013
14. Lin M-H, Kamel H, Singer DE, et al. (2019) Perioperative/Postoperative atrial fibrillation and risk of subsequent

stroke and/or mortality. Stroke 50: 1364-1371. https://doi.org/10.1161/strokeaha.118.023921

15. Butt JH, Olesen JB, Havers-Borgersen E, et al. (2018) Risk of thromboembolism associated with atrial fibrillation following noncardiac surgery. J Am Coll Cardiol 72: 2027-2036. https://doi.org/10.1016/j.jacc.2018.07.088

16. Elharram M, Samuel M, AlTurki A, et al. Anticoagulant use and the risk of thromboembolism and bleeding in postoperative atrial fibrillation after noncardiac surgery. Can J Cardiol 37: 391-399. https://doi.org/10.1016/j.cjca.2020.08.023

17. Butt JH, Olesen JB, Gundlund A, et al. (2019) Long-term thromboembolic risk in patients with postoperative atrial fibrillation after left-sided heart valve surgery. JAMA Cardiol 4: 1139-1147. https://doi.org/10.1001/jamacardio.2019.3649

18. Helgadottir S, Sigurdsson MI, Ingvarsdottir IL, et al. (2012) Atrial fibrillation following cardiac surgery: risk analysis and long-term survival. J Cardiothorac Surg 7: 87. https://doi.org/10.1186/1749-8090-7-87

19. Chebbout R, Heywood EG, Drake TM, et al. (2018) A systematic review of the incidence of and risk factors for postoperative atrial fibrillation following general surgery. Anaesthesia 73: 490-498. https://doi.org/10.1111/anae.14118

20. Vaporciyan AA, Correa AM, Rice DC, et al. (2004) Risk factors associated with atrial fibrillation after noncardiac thoracic surgery: analysis of 2588 patients. J Thorac Cardiovasc Surg 127: 779-786. https://doi.org/10.1016/j.jtcvs.2003.07.011

21. Bessissow A, Khan J, Devereaux PJ, et al. (2015) Postoperative atrial fibrillation in non-cardiac and cardiac surgery: an overview. J Thromb Haemost 13: S304-S312. https://doi.org/10.1111/jth.12974

22. Weiser TG, Haynes AB, Molina G, et al. (2015) Estimate of the global volume of surgery in 2012: an assessment supporting improved health outcomes. Lancet 385: S11. https://doi.org/10.1016/s0140-6736(15)60806-6

23. Higuchi S, Kabeya Y, Matsushita K, et al. (2019) Perioperative atrial fibrillation in noncardiac surgeries for malignancies and one-year recurrence. Can J Cardiol 35: 1449-1456. https://doi.org/10.1016/j.cjca.2019.07.008

24. Walsh SR, Tang T, Gaunt ME, et al. (2006) New arrhythmias after non-cardiothoracic surgery. BMJ 333: 715. https://dx.doi.org/10.1136/bmj.333.7571.715

25. Hyun J, Cho MS, Nam GB, et al. (2021) Natural course of new-onset postoperative atrial fibrillation after noncardiac surgery. J Am Heart Assoc 10: e018548. https://doi.org/10.1161/jaha.120.018548

26. El-Chami MF, Merchant FM, Smith P, et al. (2016) management of new-onset postoperative atrial fibrillation utilizing insertable cardiac monitor technology to observe recurrence of af (MONITOR-AF). Pacing Clin Electrophysiol 39: 1083-1089. https://doi.org/10.1111/pace.12949

27. Lowres N, Mulcahy G, Jin K, et al. (2018) Incidence of postoperative atrial fibrillation recurrence in patients discharged in sinus rhythm after cardiac surgery: a systematic review and meta-analysis. Interact Cardiovasc Thorac Surg 26: 504-511. https://doi.org/10.1093/icvts/ivx348

28. AlTurki A, Marafi M, Proietti R, et al. (2020) Major adverse cardiovascular events associated with postoperative atrial fibrillation after noncardiac surgery: a systematic review and meta-analysis. Circ Arrhythm Electrophysiol 13: e007437. https://doi.org/10.1161/circep.119.007437

29. Joshi KK, Tiru M, Chin T, et al. Postoperative atrial fibrillation in patients undergoing non-cardiac non-thoracic surgery: A practical approach for the hospitalist. Hosp Pract (1995) 43: 235-244. https://doi.org/10.1080/21548331.2015.1096181

30. Tamis JE, Steinberg JS (2000) Atrial fibrillation independently prolongs hospital stay after coronary artery bypass surgery. Clin Cardiol 23: 155-159. https://doi.org/10.1002/clc.4960230305

31. Almassi GH, Wagner TH, Carr B, et al. (2015) Postoperative atrial fibrillation impacts on costs and one-year clinical outcomes: the veterans affairs randomized on/off bypass trial. Ann Thorac Surg 99: 109-114. https://doi.org/10.1016/j.athoracsur.2014.07.035

32. Kim MH, Johnston SS, Chu BC, et al. (2011) Estimation of total incremental health care costs in patients with atrial fibrillation in the United States. Circ Cardiovasc Qual Outcomes 4: 313-320. https://doi.org/10.1161/circoutcomes.110.958165

33. Bhave PD, Goldman LE, Vittinghoff E, et al. (2012) Incidence, predictors, and outcomes associated with postoperative atrial fibrillation after major noncardiac surgery. Am Heart J 164: 918-924. https://doi.org/10.1016/j.ahj.2012.09.004

34. Smith H, Yeung C, Gowing S, et al. (2018) A review and analysis of strategies for prediction, prevention and management of post-operative atrial fibrillation after non-cardiac thoracic surgery. J Thorac Dis 10: S3799-s3808. https://dx.doi.org/10.21037/jtd.2018.09.144

35. Passman RS, Gingold DS, Amar D, et al. (2005) Prediction rule for atrial fibrillation after major noncardiac thoracic surgery. Ann Thorac Surg 79: 1698-1703. https://doi.org/10.1016/j.athoracsur.2004.10.058

36. Mariscalco G, Biancari F, Zanobini M, et al. (2014) Bedside tool for predicting the risk of postoperative atrial fibrillation after cardiac surgery: the POAF score. J Am Heart Assoc 3: e000752. https://doi.org/10.1161/jaha.113.000752

37. Kashani RG, Sareh S, Genovese B, et al. (2015) Predicting postoperative atrial fibrillation using CHA2DS2-VASc scores. J Surg Res 198: 267-272. https://doi.org/10.1016/j.jss.2015.04.047

38. Chua SK, Shyu KG, Lu MJ, et al. Clinical utility of CHADS2 and CHA2DS2-VASc scoring systems for predicting postoperative atrial fibrillation after cardiac surgery. J Thorac Cardiovasc Surg 146: 919-926.e911. https://doi.org/10.1016/j.jtcvs.2013.03.040

39. Chen YL, Zeng M, Liu Y, et al. CHA(2)DS(2)-VASc score for identifying patients at high risk of postoperative atrial fibrillation after cardiac surgery: a meta-analysis. Ann Thorac Surg 109: 1210-1216. https://doi.org/10.1016/j.athoracsur.2019.07.084

40. Iwata T, Nagato K, Nakajima T, et al. (2016) Risk factors predictive of atrial fibrillation after lung cancer surgery. Surg Today 46: 877-886. https://doi.org/10.1007/s00595-015-1258-4

41. Ishibashi H, Wakejima R, Asakawa A, et al. Postoperative atrial fibrillation in lung cancer lobectomy-analysis of risk factors and prognosis. World J Surg 44: 3952-3959. https://doi.org/10.1007/s00268-020-05694-w

42. Yamashita K, Hu N, Ranjan R, et al. (2019) Clinical risk factors for postoperative atrial fibrillation among patients after cardiac surgery. Thorac Cardiovasc Surg 67: 107-116. https://doi.org/10.1055/s-0038-1667065

43. Lahiri MK, Fang K, Lamerato L, et al. (2011) Effect of race on the frequency of postoperative atrial fibrillation following coronary artery bypass grafting. Am J Cardiol 107: 383-386. https://doi.org/10.1016/j.amjcard.2010.09.032

44. Sun X, Hill PC, Lowery R, et al. Comparison of frequency of atrial fibrillation after coronary artery bypass grafting in African Americans versus European Americans. Am J Cardiol 108: 669-672. https://doi.org/10.1016/j.amjcard.2011.04.013

45. Gryskiewicz KA, Gillespie EL, White CM, et al. (2006) Impact of hispanic ethnicity on the likelihood of developing postoperative atrial fibrillation. Conn Med 70: 77-79.

46. Zhang W, Liu W, Chew ST, et al. (2016) A clinical prediction model for postcardiac surgery atrial fibrillation in an asian population. Anesth Analg 123: 283-289. https://doi.org/10.1213/ane.0000000000001384

47. Hsu JC, Huang CY, Chuang SL, et al. (2021) Long term outcome of postoperative atrial fibrillation after cardiac surgery-a propensity score-matched cohort analysis. Front Cardiovasc Med 8: 650147. https://doi.org/10.3389/fcvm.2021.650147