Society of Cardiovascular Anesthesiologists/European Association of Cardiothoracic Anaesthetists Practice Advisory for the Management of Perioperative Atrial Fibrillation in Patients Undergoing Cardiac Surgery

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Postoperative atrial fibrillation (poAF) is the most common adverse event after cardiac surgery and is associated with increased morbidity, mortality, and hospital and intensive care unit length of stay. Despite progressive improvements in overall cardiac surgical operative mortality and postoperative morbidity, the incidence of poAF has remained unchanged at 30%–50%. A number of evidence-based recommendations regarding the perioperative management of atrial fibrillation (AF) have been released from leading cardiovascular societies in recent years; however, it is unknown how closely these guidelines are being followed by medical practitioners. In addition, many of these society recommendations are based on patient stratification into "normal" and "elevated" risk groups for AF, but criteria for that stratification have not been clearly defined. In an effort to improve the perioperative management of AF, the Society of Cardiovascular Anesthesiologists (SCA) Clinical Practice Improvement Committee developed a multidisciplinary Atrial Fibrillation Working Group that created a summary of current best practice based on a distillation of recent guidelines from professional societies involved in the care of cardiac surgical patients. An evidence-based set of survey questions was then generated to describe the current practice of perioperative AF management. Through collaboration with the European Association of Cardiothoracic Anaesthetists (EACTA), that survey was distributed to the combined memberships of both the SCA and EACTA, yielding 641 responses and resulting in the most comprehensive understanding to date of perioperative AF management in North America, Europe, and beyond. The survey data demonstrated the broad range of therapies utilized for the prevention and treatment of poAF, as well as a spectrum of adherence to published guidelines. With the goal of improving adherence, a graphical advisory tool was created with an easily accessible format that could be utilized for bedside management. Finally, given that no evidence-based threshold currently exists to differentiate patients at normal risk to develop poAF from those at elevated risk, the SCA/EACTA AF working group created a list of poAF risk factors using expert opinion and based on published risk score models for poAF. This approach allows stratification of patients into risk groups and facilitates adherence to the evidence-based recommendations summarized in the graphical advisory tool. It is our hope that these new additions to the clinical toolkit for the management of perioperative AF will improve the evidence-based care and outcomes of cardiac surgical patients worldwide. (Anesth Analg 2019;128:33–42)

Atrial fibrillation (AF) is the most common cardiac arrhythmia and affects 33 million individuals worldwide, including 6 million individuals in the United States.[1] This prevalence leads to a 37% lifetime risk of developing AF in those >55 years of age[2] and carries a $26 billion (USD) annual health care cost, which is expected to double in the next 25 years.[3]

In the cardiac surgical population, postoperative AF (poAF) is the most common adverse event,[2] and its incidence increases with older age, increased surgical complexity, and

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a history of AF. Across numerous studies, the incidence of poAF is reported at 30% after isolated coronary artery bypass graft (CABG) surgery, 40% after valve replacement or repair, and 50% after combined CABG/valvular procedures.[4–7] Of all cardiac surgical patients who experience poAF, 70% develop it before the end of the fourth postoperative day and 94% by the seventh postoperative day.[4] PoAF is associated with increased morbidity,[8] mortality,[8,9] intensive care unit and hospital length of stay,[10,11] and health care utilization.[6,12] However, despite concurrent improvement in the rate of other postoperative morbidities and operative mortality, the reported incidence of poAF has remained remarkably steady over recent decades.

Existing guidelines support utilizing prevention and treatment efforts throughout the perioperative period, which encompasses the days leading up to the operation, the operation itself, and the immediate postoperative period.[13–15] The Society of Cardiovascular Anesthesiologists (SCA) Clinical Practice Improvement Committee, supported by a collaboration with the European Association of Cardiothoracic Anaesthetists (EACTA), developed a multidisciplinary Atrial Fibrillation Working Group with the goal to enhance care of cardiovascular surgical patients by creating recommendations for best practice around prevention and management of poAF and disseminating such recommendations via educational efforts and societal communications.

In this Practice Advisory, we share the following updates and results with the clinical community:

- A summary of current best practice evidence and guidance for the prevention and treatment of poAF after cardiac surgery,
- The results of the most comprehensive survey to date describing current clinical practice patterns for poAF management in North America, Europe, and other countries,
- An assessment of barriers to the implementation of best practice guidelines regarding poAF management,
- A new, simple graphical "Best Practice Advisory for the prevention and treatment of poAF after Cardiac Surgery" by the SCA and EACTA, and
- Risk factors to identify cardiac surgical patients at elevated risk of developing poAF based on an analysis of existing literature.

METHODS

Guideline Review

We evaluated all national and international guidelines with recommendations for the prevention and treatment of poAF after cardiac surgery that were written in English and published directly by a society involved in the care of cardiac surgical patients or endorsed and published in collaboration with other similar societies. Reference lists of publications on AF were reviewed from US, Canadian, Asian, Australian, and European cardiac surgical societies. The final list included the American Association for Thoracic Surgery, American College of Cardiology (ACC), American Heart Association (AHA), American College of Cardiology Foundation, Heart Rhythm Society, European Heart Rhythm Association, European Society of Cardiology (ESC), European Association for Cardio-Thoracic Surgery (EACTS), Canadian Cardiovascular Society, SCA, and Society of Thoracic Surgeons (STS). In addition, we included the recommendations from the UK National Institute for Health and Care Excellence. In total, this yielded 6 guidelines: the 2014 AHA/ACC/Heart Rhythm Society Guideline for the Management of Patients with Atrial Fibrillation,[16] 2014 ESC/EACTS Guidelines on Myocardial Revascularization,[17] 2016 ESC Guidelines for the Management of Atrial Fibrillation developed in collaboration with EACTS,[18] 2010 Canadian Cardiovascular Society Atrial Fibrillation guidelines,[19] 2014 Management of Atrial Fibrillation: Summary of updated National Institute for Health and Care Excellence guidance (2017 update),[20] and 2011 American College of Cardiology Foundation/AHA guideline for CABG surgery.[21] Furthermore, the expert members on the panel attended relevant scientific meetings in Europe and the United States during 2015–2018 to ensure up-to-date awareness of the newest insights in this clinical area. All recommendations from these guidelines were compiled, and those that achieved a IIb or better class of recommendation were consolidated into a summary table (Table 1; Supplemental Digital Content, Table 1, http://links.lww.com/AA/C618).

Multinational Survey of Cardiac Anesthesiologists

Survey Design. The objective of these descriptive surveys was to ascertain the current practice patterns of poAF prophylaxis and treatment in the perioperative context among a cohort of providers distributed across the globe. The Institutional Review Board at Partners Healthcare approved the study, waiving the requirement for written informed consent because identifying information was not collected. We developed a qualitative survey investigating the clinical practice of perioperative AF management composed of 5 demographic/practice patterns and 10 content questions (Supplemental Digital Content, Figure 1, http://links.lww.com/AA/C618). The survey design was a collaborative and iterative effort of the AF working group. SCA and EACTA survey questions were the same; however, the EACTA survey included an additional response option to several questions to reflect different prevention and treatment strategies in Europe.

All questions queried interventions with an evidence base and class of recommendation of either I or IIa in ≥1 guideline.[16–21] The majority of guidelines used evidence-based methodologies developed by the ACC/AHA Task Force (Supplemental Digital Content, Figure 2, http://links.lww.com/AA/C618).[22] As shown in Table 1 and Supplemental Digital Content, Table 1, http://links.lww.com/AA/C618, most of these recommendations are similar across several guidelines. Questions in the survey were based on the 6 guidelines regarding the prophylaxis and treatment of poAF in the perioperative cardiac surgery setting.

Before circulation, the survey was tested with a multidisciplinary group of medical practitioners (N = 15) caring for cardiac surgical patients with AF to assess the strength of content, clarity, time to completion, and redundancy. Modifications were made based on their feedback.

Table 1. Summary of Recommendations for the Clinical Management of Perioperative Atrial Fibrillation

Clinical Recommendation	Recommendation Class	Level of Evidence	Reference
Perioperative oral β-blocker therapy is recommended for the prevention of postoperative AF after cardiac surgery.	I	A/B	17,18,21
A nondihydropyridine calcium channel blocker or β-blocker is recommended to achieve rate control with postoperative AF.	I/IIa/NC	B/low	16,20,21
Restoration of sinus rhythm by electrical cardioversion or antiarrhythmic drugs is recommended in postoperative AF with hemodynamic instability.	I	C	18
Perioperative amiodarone should be considered to prevent AF after cardiac surgery.	IIa	A/B	16–18,21
Asymptomatic postoperative AF should initially be managed with rate control and anticoagulation.	IIa/NC	B/low	18,20
Long-term anticoagulation should be considered in patients with postoperative AF, considering individual stroke and bleeding risk.	IIa	B/C	17,18
Antiarrhythmic drugs or direct current cardioversion should be considered for symptomatic postoperative AF after cardiac surgery in an attempt to restore sinus rhythm.	IIa	B/C	16,18
Intravenous vernakalant may be considered for cardioversion of postoperative AF in patients without severe heart failure, hypotension, or severe structural heart disease (especially aortic stenosis).	IIb	B	18
Colchicine may be considered postoperatively to reduce AF after cardiac surgery.	IIb	B	16
Statin use prevents postoperative AF but is equivocal.	NC	…	19
Digoxin does not reduce postoperative AF.	NC	low	20

All recommendations were included with class of recommendation IIb or better in ≥1 guideline.[16–21] The majority of guidelines used evidence-based methodologies developed by the task force (Supplemental Digital Content, Figure 2, http://links.lww.com/AA/C618).[46] Classes of recommendations are as follows: class I: is recommended; class IIa: is reasonable; class IIb: may be reasonable; class III: is not recommended.[20] Level of evidence A: data derived from multiple randomized clinical trials or meta-analyses. Level of evidence B: data derived from a single randomized clinical trial or large nonrandomized studies. Level of evidence C: consensus of opinion of the experts and/or small studies, retrospective studies, registries.

Abbreviations: AF, atrial fibrillation; NC, no classification; NICE, National Institute for Health and Care Excellence; RCT, randomized controlled trial.

Survey Distribution. The survey was administered separately to the respective societies' membership in 2015, with the collaboration between SCA and EACTA established in spring of that year. EACTA membership extends beyond the geographical boundaries of Europe, with members in the Middle East, Australasia, and parts of Africa, among others. The first invitation to the survey was sent to active SCA members (N = 2430) via email on February 13, 2015 using a web-based survey tool (http://www.surveymonkey.com), with a follow-up email 1 week later. The survey was sent to the European Association of Cardiothoracic Anesthesiologists (EACTA) members (N = 745) on September 23, 2015, using a different web-based software (http://www.questionpro.com) with 4 follow-up emails over the ensuing month. The survey platforms were different because both the SCA and EACTA had established standard tools for surveying its members. The authors were blinded to respondents' contact information.

Statistical Analysis. Summary data for each question included those with a complete response for that question. As not every question was answered by all respondents, there was variability in the number of respondents for each question. The design, methodology, and limitations of these descriptive surveys do not allow for any causal or conclusive statistical analysis.

Creation of Practice Advisory. To best summarize the multitude of different guidelines and recommendations, as well as the new risk score, in 1 easily accessible format, we created a graphical practice advisory for the practicing clinician that could be displayed at the point of care, consolidating the evidence for the "prevention" and "treatment" of poAF after cardiac surgery (Figure). Based on literature review and discussion within the advisory group, we included all class I, IIa, and IIb recommendations from the existing guidelines, choosing the highest recommendation if there were overlap (eg, level of evidence [LOE] A over B and class I over IIa). None of the data presented in the prevention and treatment sections of the graphical guidance tool is new or original; all data included within are previously published. The practice advisory underwent multiple iterations leading to a simplified distillate of all the published guidelines. It was then reviewed by the expert panel and 12 cardiac anesthesia, surgical, and critical care colleagues at the Barts Heart Centre in London, United Kingdom, and Brigham and Women's Hospital, Boston, MA. The expert panel unanimously endorsed the final practice advisory.

AF Risk Stratification Model. Currently, no evidence-based threshold exists to differentiate patients at normal risk for developing perioperative AF from those at elevated risk. Nevertheless, multiple guidelines make recommendations based on this distinction in risk level without supplying a framework for stratification. Given the multiple variations of recommendations and the absence of a definitive risk score endorsed by the professional societies, the "SCA/EACTA Clinical Practice Improvement Advisory Group on Perioperative Atrial Fibrillation in Patients undergoing Cardiac Surgery" conducted a separate literature search to gather an overview of published evidence about risk factors for the development of poAF after cardiac surgery. On July 10, 2017, the following search operations were performed in PubMed: "risk score" OR "risk index" OR "prediction" OR "risk algorithm" AND ("atrial fibrillation" AND "cardiac surgery"). In addition, after review of reference lists and consideration of the expert group's familiarity with the published literature, 6 additional publications were included. This resulted in 20 publications (Supplemental Digital Content, Table 2, http://links.lww.com/AA/C618). Of those publications, 8 were excluded for a sample size

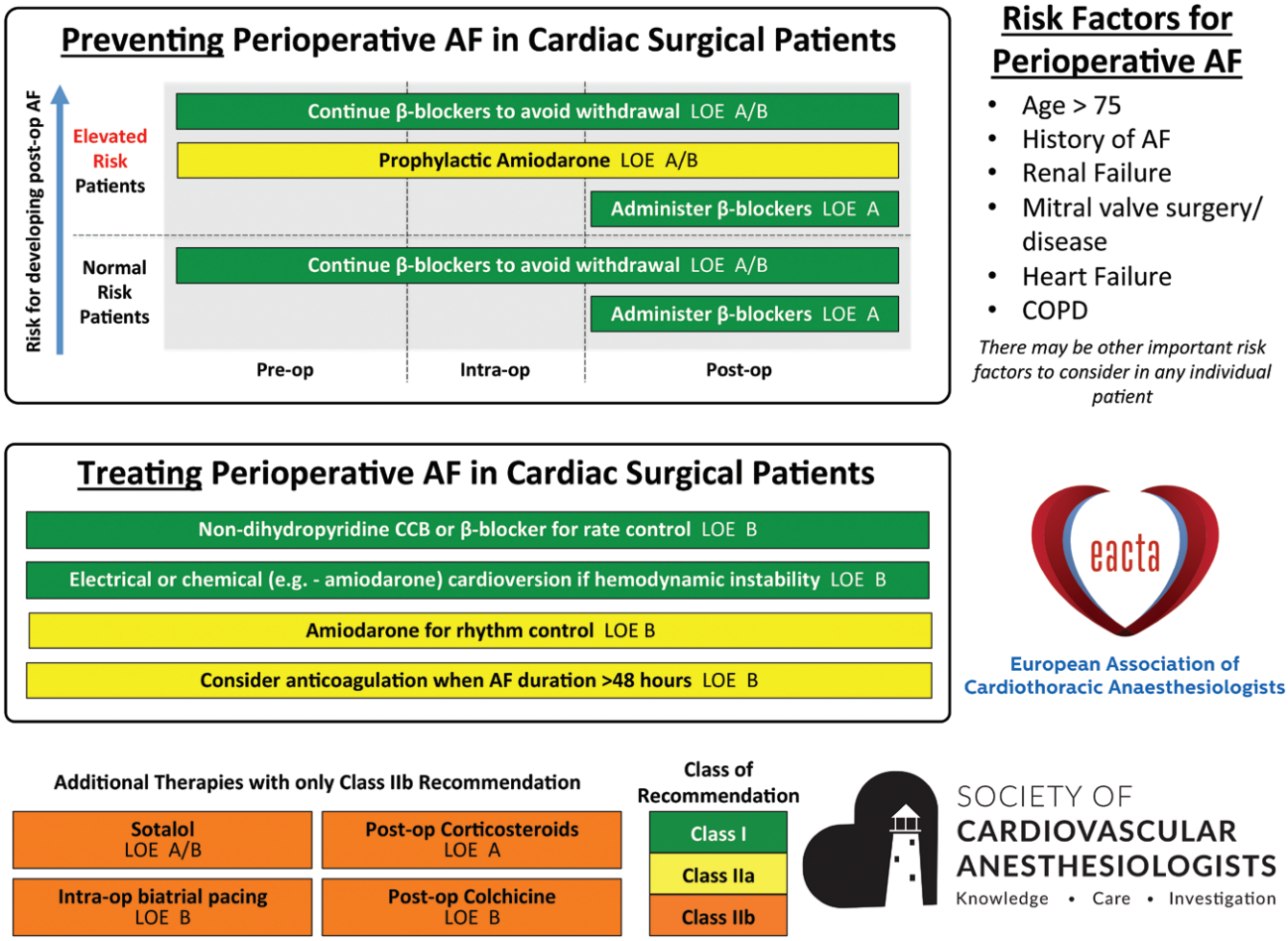

Figure. Graphical practice advisory tool for the prevention and treatment of perioperative AF in the cardiac surgical patient. The top left portion of the graphic represents strategies with good evidence for prevention of perioperative AF in cardiac surgical patients. The middle left shows strategies with good evidence for treatment of AF after cardiac surgery. The bottom left shows risk factors associated with poAF. The right side shows prophylaxis and treatment strategies that meet level IIb LOE, for which the usefulness is unclear or not well established. AF indicates atrial fibrillation; CCB, calcium channel blocker; COPD, chronic obstructive pulmonary disease; Intra-op, intraoperative; LOE, level of evidence; MV, mitral valve; poAF, postoperative atrial fibrillation; Post-op, postoperative; Pre-op, preoperative.

<100 using the same congestive heart failure, hypertension, age >75 (doubled), diabetes, stroke (doubled), vascular disease, age 65–74, and sex (female) (CHA_2DS_2VASc) or being a meta-analysis. Furthermore, several studies were excluded after further review, some for incongruencies in the variables presented (Supplemental Digital Content, Methods 1, http://links.lww.com/AA/C618).

Based on the existing information in the literature, the expert panel further discussed risk factors (Supplemental Digital Content, Table 3, http://links.lww.com/AA/C618), including consideration of ongoing research projects and large-scale registry work. This effort resulted in an expert opinion consensus on risk factors for poAF (Table 2), allowing the practitioner to separate patients into "normal risk" and "elevated risk" categories corresponding to categories established in the guidelines and reproduced in the practice advisory.

RESULTS

Survey Data

Survey Respondent Characteristics. The survey (Supplemental Digital Content, Figure 1, http://links.lww.com/AA/C618) was presented to 3175 possible participants (SCA membership: N = 2430; EACTA membership: N = 745) and resulted in 641 unique complete responses (SCA respondents: N = 262, response rate = 11%; EACTA respondents: N = 379, response rate = 51%; some individual questions yielded a higher number of responses) for an overall response rate of 20%. Both survey platforms measure the time it takes respondents to complete the questionnaire, and the average time both within each group and across both surveys was 10 minutes. The respondents were distributed across the globe with relative concentrations in Europe and North America (as determined by IP address analysis, Supplemental Digital Content, Table 4, http://links.lww.com/AA/C618). In terms of training background, essentially all respondents were MD or equivalent trained, and a notable majority had undertaken subspecialty fellowship training in cardiac anesthesiology (SCA, 76%; EACTA, 82%) (Supplemental Digital Content, Table 5, http://links.lww.com/AA/C618). There was an even distribution of clinical practice experience in both society cohorts ranging from 0 to 5 years to >25 years. Respondents in both groups worked throughout the spectrum of clinical settings, including academic medical centers, nonacademic

Table 2. Risk Factors for Postoperative Atrial Fibrillation

Risk Factors
Age
History of atrial fibrillation
Renal failure
Mitral valve surgery/disease
Heart failure
Chronic obstructive pulmonary disease

Risk factors that put patients at elevated risk of developing poAF based on published risk scores and expert consensus.

medical centers, and private practice contexts, although a greater percentage of EACTA respondents provided care in an academic setting, with a larger proportion of SCA respondents working in private practice.

Perioperative AF Management Patterns. *Prophylactic Use of β-Receptor Antagonists.* The use of β-receptor antagonists to prevent poAF for patients undergoing cardiac surgery has a class I recommendation supported by LOE A and LOE B data. Among the "SCA "and "EACTA" respondents, the use of prophylactic β-blockers in patients who are in sinus rhythm but are at high risk for developing poAF was assessed in 2 perioperative periods: (1) pre- and intraoperatively, and (2) immediately postoperatively (defined as within 24 hours). In the pre- and intraoperative periods, SCA respondents demonstrated a bimodal distribution where 30% of the cohort gave prophylactic β-blockade to <10% of their high-risk patients, while another 31% used it in >90% of patients (Supplemental Digital Content, Figure 3A, http://links.lww.com/AA/C618). In the EACTA cohort, almost half of all respondents used prophylactic β-antagonists in <10% of their patients. The use of β-blockers by SCA respondents to prevent development of poAF in the immediate postoperative period also demonstrated 2 divergent groups, with 29% of respondents using it <10% of the time and another 32% using it >90% of the time (Supplemental Digital Content, Figure 3B, http://links.lww.com/AA/C618). The EACTA respondents' practice patterns in this context were again different, with 32% using β-antagonists in <10% of their patients, about one-third using it in 20%–80% of their patients, and only 14% reporting use in >90% of their high-risk patients. When survey respondents were asked how the AHA class I, LOE A guideline that recommends prophylactic postoperative β-blockade to reduce risk for poAF affected their clinical practice, 79% of all practitioners responding to this question believed that they follow this guideline either "sometimes" or "nearly always" (Supplemental Digital Content, Table 6, http://links.lww.com/AA/C618). Among those respondents who do not give β-blockers to their high-risk patients in the perioperative period, data were also collected on the primary reason that administration was avoided. For respondents from the SCA cohort, the risk for bradycardia was cited as the most common barrier to pre- and intraoperative use, followed by the belief that the overall risks outweighed the benefits and the concern that β-antagonist use did not have a benefit in this setting (Supplemental Digital Content, Figure 4A, http://links.lww.com/AA/C618). EACTA respondents have a different perception of barriers, with a majority of respondents concerned that the potential risks were greater than the benefits, with less specific concern about the risk for bradycardia. Fourteen percent did not believe that the pre- and/or intraoperative β-blockade was beneficial. The reported barriers to use in the immediate postoperative period were largely identical to the patterns seen in the pre- and intraoperative data (Supplemental Digital Content, Figure 4B, http://links.lww.com/AA/C618), with bradycardia noted as the primary concern for the SCA group, and a majority of EACTA respondents citing an unfavorable risk-to-benefit ratio.

Prophylactic Use of Amiodarone. A class IIa recommendation based on LOE A and LOE B data supports the use of prophylactic amiodarone in patients who are at the time in normal sinus rhythm but are deemed to be at high risk of developing poAF. In the SCA group, 59% of respondents used prophylactic amiodarone in <10% of their high-risk cardiac surgical patients (Supplemental Digital Content, Figure 5, http://links.lww.com/AA/C618). There was similar reluctance within the EACTA cohort to use amiodarone in this context, with 78% of respondents using it in <10% of their high-risk patients. Among SCA respondents who did not use prophylactic amiodarone, the most common reason given was that the risks outweighed the benefits, followed by resistance from surgical colleagues and concern that amiodarone does not have a benefit in this context (Supplemental Digital Content, Figure 6, http://links.lww.com/AA/C618). Similarly, a majority of responding providers in the EACTA group felt that the risks of amiodarone outweighed the benefits, while 28% believed that amiodarone does not provide benefit and 6% encountered surgeon opposition.

Other Prophylactic and Treatment Therapies. Survey data were also collected on the breadth of therapies that were regularly used by respondents as prophylaxis against the development of poAF (Table 3). Within the SCA cohort, β-antagonists were the most common prophylactic medical therapy, followed by amiodarone, magnesium, and statins. Interventions such as atrial pacing were reported by 20% of SCA members and performance of a prophylactic maze procedure by 13%. EACTA respondent data showed notably greater use of magnesium, digoxin, and atrial pacing but revealed similar rates of prophylactic β-blocker, amiodarone, and statin therapy as well as prophylactic maze procedures. An additional answer option in the EACTA survey highlighted that 69% of respondents target high–normal blood potassium levels to prevent AF after cardiac surgery.

Additional responses were elicited from the surveyed practitioners regarding the management strategies that were routinely used to "treat" poAF in their cardiac surgical patients (Table 3). Among the SCA cohort, the mainstays of medical management were amiodarone and β-antagonists, with less frequent use of magnesium, nondihydropyridine calcium channel blockers, and digoxin, as well as rare use of other antiarrhythmic drugs such as sotalol and procainamide. Nonpharmacological interventions were also performed including cardioversion and rapid atrial pacing. When compared to this practice pattern, the EACTA respondents similarly used amiodarone as their most common

Table 3. Therapies That Are Routinely Applied "Prophylactically" and as "Treatment" to Cardiac Surgical Patients at High Risk of Developing Atrial Fibrillation

	Prophylaxis, %		Treatment, %	
Therapy	**SCA**	**EACTA**	**SCA**	**EACTA**
β-Blockers	60	53	80	66
Amiodarone	39	34	93	95
Magnesium	37	65	35	70
Atrial pacing	20	32	…	…
Statins	16	19	7	8
Prophylactic Cox maze procedure	13	13	…	…
Nondihydropyridine calcium channel blockers (verapamil and diltiazem)	4	4	19	7
Steroids	5	5	0	3
Sotalol	3	4	5	7
Colchicine	2	1	0	1
Digoxin	2	8	14	26
Propafenone	0	2	0	3
Procainamide	0	0	2	1
Maintenance of high–normal serum potassium levels[a]	N/A	65	N/A	69
Other[a]	N/A	7	N/A	3
None	12	N/A	…	…
Rapid atrial pacing	…	…	9	19
Cardioversion	…	…	63	73

Abbreviations: EACTA, European Association of Cardiothoracic Anaesthetists; N/A, not applicable; SCA, Society of Cardiovascular Anesthesiologists.
[a]Additional response only listed on EACTA survey.

therapy but were less likely to use β-antagonists or calcium channel blockers. They use magnesium, digoxin, and nonpharmacological interventions such as cardioversion and rapid pacing at higher rates than their SCA counterparts. In keeping with the findings on methods to prevent AF, 73% of EACTA respondents target a high–normal serum potassium level during the treatment of poAF. In addition, therapies such as steroids, propafenone, and colchicine were used with low frequency in the EACTA respondents but were not reported at all by SCA respondents. When asked about the effect on their practice of the AHA class I, LOE A guideline that recommends β-antagonists as treatment after the development of poAF, 88% of the combined society cohorts reported that they followed this guideline either sometimes or nearly always (Supplemental Digital Content, Table 6, http://links.lww.com/AA/C618).

Graphical Best Practice Advisory

The mainstays of the practice advisory are a combination of well-validated interventions with class of recommendation I or IIA and primarily LOE A or B. The graphical decision-making tool differentiates between normal risk and elevated risk; however, the current evidence does not allow for discreet prospective risk stratification predicting the likelihood of poAF. This necessitated the creation of poAF risk factors derived from published data as described below.

Patient Risk Stratification for the Development of AF After Cardiac Surgery

A limited number of publications describe a methodologically robust process to delineate risk factors specifically for the development of poAF after cardiac surgery, and, notably, the final risk models often differ significantly. This may be explained by factors such as the cardiac surgical population included (eg, CABG versus valve surgery), the risk factors available to the researchers (eg, medications, echocardiographic parameters), type of analysis (prospective versus retrospective study), or the ethnicity of the study population. Therefore, we list risk factors based on the currently available, published, and scientifically robust risk scores (Supplemental Digital Content, Table 3, http://links.lww.com/AA/C618) along with our expert consensus. This resulted in 6 risk factors that significantly increase the risk of developing poAF: age, history of AF, renal failure, mitral valve surgery/disease, heart failure, and chronic obstructive pulmonary disease. We elected not to define the severity of the diseases or create individual cutoffs as we wanted to stay as close to the individual risk scores as possible, and they used different definitions. Similarly, we did not choose a cutoff to define when a patient is considered elevated risk according to their percent risk of poAF, leaving both decisions to the treating clinician.

DISCUSSION

The occurrence of new-onset poAF is associated with increased short- and long-term morbidity and mortality,[10,23,24] increased intensive care and hospital length of stay,[25] and increased costs of care.[4,10,26] Numerous guidelines from the leading cardiovascular societies have made recommendations for the prevention and treatment of poAF, yet it was unclear how consistently they were being followed by front-line clinical providers. Our survey suggests that, despite awareness of the existence of guideline recommendations (including class I recommendations supported by multiple clinical trials), the majority of responding practitioners selectively follow these recommendations. We did not explore in detail which professional groups (surgeons, cardiologists, anesthesiologists, intensive care physicians) manage the decisions relating to prevention and treatment of poAF. We believe that the members' responses reflect practice at their institution, but we have not evaluated this theory in more detail.

Multiple guidelines make management recommendations based on patients at normal or elevated risk yet do not define the criteria for that stratification. Therefore, by convening an expert multidisciplinary panel and analyzing all the currently published guidelines and risk scores in detail, we have devised a simple visual practice advisory to guide the perioperative management of cardiac surgical patients, and we have identified risk factors that can help define the elevated risk designation for the development of poAF to reduce the incidence and prevalence of poAF.

The overall purpose of this publication is not to discuss specific scientific aspects of treating poAF or assess the pros and cons of certain medications, as this has been done at length in other studies and will undoubtedly continue, but rather to (1) demonstrate the implementation gap that exists between generalizable knowledge and clinical practice patterns, and (2) attempt to bridge that gap with accessible and unambiguous content. We have synthesized and distilled a vast amount of imperfect and evolving guideline information and integrated the current evidence into a pragmatic,

easily understandable graphical display and explanatory document that can be widely disseminated and consistently applied.

Consistency in the implementation of evidence has the potential to vastly improve patient outcome and health care resource utilization. In 2013, the Society for Thoracic Surgeons (STS) captured 281,807 cardiac surgical procedures in their database,[27] and the UK Society for Cardiac and Thoracic Surgery audit captured 36,134 cardiac surgical procedures.[28] Assuming the lowest reported incidence of poAF of 30%, ≥95,382 patients would have developed poAF after cardiac surgery in the United States and United Kingdom in 2013. A 1% reduction in the incidence of poAF after cardiac surgery, through the consistent application of prophylactic measures, could result in 3000 more AF-free patients and 15,000 fewer hospital days, or a reduction of hospital length of stay for affected patients by an average of 5 days.[4]

Current Best Practice: Management of poAF

The exact mechanism of initiation and maintenance of AF is not fully understood, but contributors include hemodynamic and metabolic stress, atrial inflammation and ischemia, catecholamine excess, and neurohumoral cascade. Furthermore, the underlying electrophysiological properties of the atria and pulmonary veins permit the development of complex patterns of conduction as seen in AF, with atrial remodeling and fibrosis contributing to the diverse mechanisms of AF pathogenesis. Pharmacotherapy attempts to prevent or interrupt these processes.

β-Blockers

β-Blockers for the prevention of poAF after cardiac surgery have been extensively studied. The majority of presenting patients are already on β-blockers for ischemic heart disease, hypertension, or impaired left ventricular dysfunction. Nevertheless, the survey reflects that patients are often not administered β-blockers or these are held for the duration of surgery, which is associated with an increased risk of poAF from β-blocker withdrawal.[29] β-Blocker withdrawal could also explain the discrepant findings that some studies do not show a benefit or even an increased rate of poAF in those patients taking β-blockers.[30,31] As with most medical interventions, therapy should be tailored to patient-specific clinical scenarios. Nevertheless, in all guidelines, the continuation of β-blockers to avoid withdrawal and the prophylactic administration in the immediate postoperative period is a class I recommendation. This is reflected in our practice advisory, which stresses the continuation and administration in normal and elevated risk individuals (class I, LOE A/B).[17,18,21]

Amiodarone. Oral or intravenously administered amiodarone is a mainstay for the prevention and chemical treatment of poAF after cardiac surgery because it has the greatest likelihood of maintaining sinus rhythm. While not prohibitively expensive and commonly used, amiodarone causes frequent and complex side effects, including bradycardia, thyroid dysfunction, pulmonary toxicity, raised serum transaminases, and reversible corneal microdeposits. As suggested by the survey responses, these side effects seem to act as a deterrent to administration even though side effects seem to correlate more closely with cumulative dose rather than serum drug levels and usually occur after months to years of administration.[32] However, case reports of fatal pulmonary toxicity within weeks do exist, perhaps tipping caregivers' perception of the risk-to-benefit ratio toward not prescribing the drug.[33,34]

While our practice advisory does recommend "prophylactic" amiodarone in elevated risk patients (class IIA, LOE A/B),[16–18,21] we do not recommend a specific dose or administration algorithm because referral and practice patterns differ between institutions and countries. It must be emphasized that, as reflected in the guidelines, a short perioperative course of amiodarone will not have the same side effect profile as a long-term course of oral amiodarone.[35,36]

While there is ample evidence demonstrating the deleterious effects of poAF after cardiac surgery, poAF treatment strategies remain controversial. A recently published randomized controlled trial of rhythm or rate control for poAF found no significant difference in length of stay, complications, mortality, or rhythm at 60 days.[37] Nevertheless, enough class of recommendation I and IIA evidence exists to recommend the following interventions in specific clinical scenarios: (1) β-blockers, (2) amiodarone, (3) direct current cardioversion, (4) calcium channel blockers, and (5) anticoagulation (for stroke prevention).

SCA/EACTA Clinical Practice Improvement Survey of Current Practice. *Patterns of Practice in the Management of Perioperative AF.* This multidisciplinary working group hypothesized that, despite compelling evidence for certain therapies, wide practice variability existed in the approach to the prevention and treatment of poAF. The extent of this variability was unknown, nor was it known if the variability could be attributed to the type of medical institution, regional location, or background of the practice provider. Therefore, a simple descriptive survey was created to gain a better understanding of the hurdles faced by the working group in the implementation phase of our proposed "Practice Advisory for Preventing and Treating Perioperative Atrial Fibrillation in Patients Undergoing Cardiac Surgery."

Our survey results suggest that both in North America and in Europe, less than a third of responding physicians routinely administered β-blockers to patients at elevated risk for poAF, and that number was even lower for prophylactic amiodarone, both of which are class I and IIa recommendations, respectively. Hence, these data suggest an unacceptably low rate of adherence to current best practice, although the limitations of our descriptive survey design and response rate do not allow firm conclusions to be drawn.

The class I recommendation for perioperative β-blockade, when not contraindicated, clear and explicit in several guidelines and now reinforced by the graphical practice advisory, should encourage caregivers to review their practice and improve compliance with current best evidence, increasing the number of patients electively treated with β-blockers before and after cardiac surgery.[17,18,21] Furthermore, a wide variety of therapies are still in use that are not contained in guidelines or have IIb or lower levels of evidence.

In addition, we analyzed descriptive variables to identify common management themes among provider subgroups

and/or institutions. We evaluated if practice patterns differ between academics and private practice, the greatest barriers to implementation of therapies with strong levels of evidence, and what specific ineffective and possible detrimental therapies are still being used. The results of our survey underline the perception of large variability in practice and limited acceptance of and adherence to existing evidence and guidelines. These limitations are neither isolated, geographical, practice type related, nor localized institutional occurrences.

Assessment of Barriers to Implementation of Best Practice. Despite exhaustive efforts to make practice more rational and evidence based, nonadherence to guidelines continues to baffle and intrigue policymakers and guideline editors. In a recent study of ophthalmologists who performed cataract surgery, >50% ordered unnecessary preoperative tests, which was the same percentage as in 1995.[38] One reason could be ambiguous and ever-changing science. For example, the US Preventive Services Task Force endorses biennial breast cancer screening for women starting at age 50, while the American Cancer Society recommends age 45 and the American College of Radiology and the Society of Breast Imaging recommend age 40.[39–41] To better understand barriers to physician adherence to clinical practice guidelines, Cabana et al[42] examined the literature for reasons for nonadherence and created a framework according to their effect on physician knowledge, attitudes, or behavior. The most common adherence barriers cited by studies were as follows: (1) lack of awareness (physicians were not aware of a certain recommendation), (2) lack of familiarity (physicians were not familiar with a guideline recommendation), (3) lack of agreement (physician disagreed with the guidelines or believed they were not worth the risk, were oversimplified, or reduced autonomy), (4) lack of self-efficacy (physician believes that they cannot perform guideline recommendation), (5) lack of outcome expectancy (physician believes that performance of guideline recommendation will not lead to desired outcome), (6) inertia of previous practice (habit, routines), or (7) external barriers that are related to patient, guidelines, or environmental factors.[42] From the results of our survey, we can speculate that caregivers are aware of the existence of guidelines and might be somewhat familiar with them. All interventions are within the normal scope of practice for caregivers in the perioperative cardiac surgery arena, so lack of self-efficacy is unlikely to present an obstacle for adherence. Therefore, lack of agreement, lack of outcome expectancy, and practice inertia seem to be the barriers to rigorous implementation of current best evidence. Furthermore, it is also possible that the plethora of different and ever-changing guidelines in this space is a major contributor to inconsistent adoption, and we believe that our easily accessible graphical guidance may make a significant contribution to overcoming the barriers to best practice.

Risk Factors for Development of AF After Cardiac Surgery. We examined all published risk scores and now present our expert consensus for identifying patients at risk for developing poAF after cardiac surgery (Table 2; Supplemental Digital Content, Tables 2 and 3, http://links.lww.com/AA/C618). Because there is no validated model to identify relative weighting and cumulative risk to define an inflection point between normal and elevated risk, we leave it to the practitioner to decide what risk factors for poAF will put patients into the elevated risk category. Emerging evidence will likely add further factors known to elevate risk or be protective.

Limitations. This effort is not without limitations. The survey response rates are low despite multiple attempts at contacting the membership. Unfortunately, this event is not isolated because other member surveys have had similarly low response rates, which leads us to believe that an overall survey fatigue might be a factor.[43–45] Like other professional associations, it is perhaps time to discuss methodology and administration of member surveys and learn from improvements other organizations have implemented. Also, future SCA/EACTA studies will be administered concomitantly now that the collaboration is established, and we will seek agreement to use a unified survey instrument and aligned practices for administering the surveys (timing and number of reinvitations, etc). That said, the demographics were reflective of the societies as a whole, and the practice patterns did reflect the wide variation also present in our expert committee. In contrast with a robust audit of practice patterns, there are obvious shortcomings of self-reported measures of guideline adherence. However, the usual criticism relates to overreporting of adherence, as opposed to nonadherence. Thus, because our responses highlight variability or even low adherence, the purpose of the survey in underscoring the need for practice improvement efforts holds true.

CONCLUSIONS AND RECOMMENDATIONS

Current multinational practice patterns for the prevention and treatment of poAF do not reflect rigorous translation of current best evidence. Efforts are required to facilitate better understanding and adherence to current best practice guidelines. We present a best practice advisory incorporating existing guidelines, but meaningful large randomized controlled trials are required to test prevention and treatment protocols. Furthermore, larger registry studies and/or prospective, purpose-designed registries will need to be interrogated to further delineate risk factors.

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