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# Improving future postoperative atrial fibrillation care: a 30,000-foot viewpoint

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## Abstract

**Aim:** In the United States (US), post-operative atrial fibrillation (POAF) is the most common complication following cardiac surgery. In order to understand the opportunities to improve POAF patients' care, this "30,000 foot" review evaluated the professional society POAF database/registry definitions and guideline recommendations.

**Methods:** All US-based professional society organizations with an interventional cardiac database/registry and/or cardiac care guidelines were identified; from these, the POAF database definitions and guideline recommendations were evaluated using a content analysis approach.

**Results:** The Society of Thoracic Surgeons (STS) POAF definition was the most frequently referenced definition (21% of key references). Only 50% ( $n = 5/10$ ) US cardiac surgery databases/registries included any POAF definition; compared to STS, the other five definitions required substantially more detailed documentation. Across eight guidelines, three different types of POAF recommendations were found: risk assessment ( $n = 3$ ); prevention ( $n = 7$ ); and management ( $n = 8$ ). As a common feature, the risk assessment strategies tended to focus on advanced age ( $n = 6$ ). Beta-blockers ( $n = 5$ ) and amiodarone ( $n = 6$ ) were common prevention approaches. Uniformly, anti-coagulation was the only management strategy ( $n = 8$ ) recommended, barring any contraindications.



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**Conclusion:** Across ten professional societies, 50% had no POAF definition; of the remaining five, no POAF definitional consistency was found. Across the eight US-based professional society POAF-related guidelines, only anticoagulation was uniformly recommended. Given these “big picture” findings, professional societies are urged to work collaboratively to harmonize these divergent POAF definitions and consolidate their evidence-based guideline recommendations to improve future POAF patients’ quality of care.

**Keywords:** Postoperative atrial fibrillation, cardiac surgery, professional society, guidelines management, guidelines management, clinical management

## INTRODUCTION

Post-operative atrial fibrillation (POAF) occurs in 20%-50% of cardiac operations and 10%-30% of non-cardiac surgeries<sup>[1,2]</sup>. Despite this high POAF rate, there is an astonishing lack of consensus among professional societies on an official POAF definition and POAF patients’ management.

Over the last decade, POAF has garnered increased attention; POAF is associated with increased hospital length of stay and costs<sup>[3]</sup>. In spite of this POAF spotlight, persistent disparities exist as to how hospitals and clinicians identify, monitor, and manage patients with a POAF complication.

### Brief history

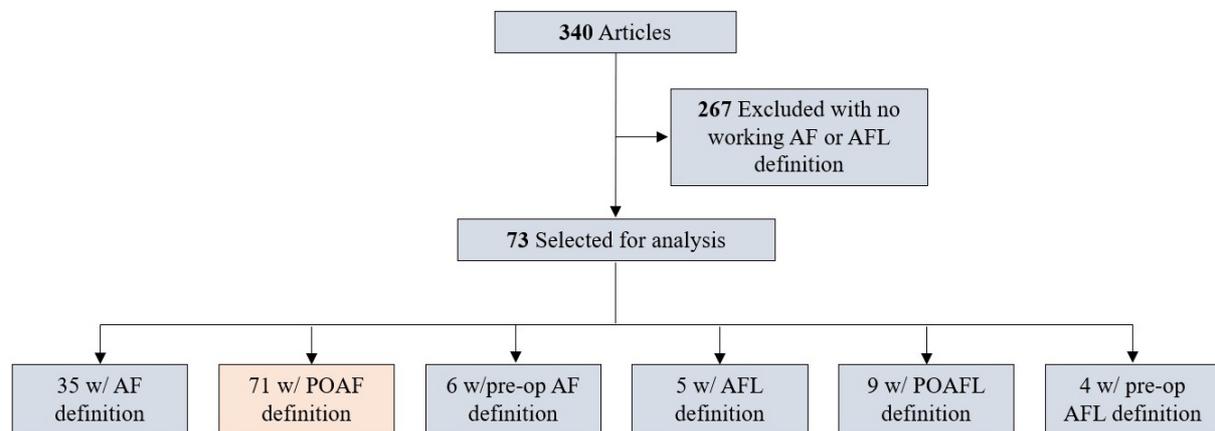
In 1966, Dr. Avedis Donabedian published his landmark quality improvement framework, which is commonly used today to evaluate healthcare quality<sup>[4]</sup>. In 1992, the Department of Veterans Affairs (VA) health care system was the first health care organization to define and monitor surgical patients’ preoperative and postoperative atrial fibrillation<sup>[5]</sup>. Based on these historical VA endeavors, the STS in 2000 published their first POAF definition (i.e., adult cardiac surgery database, version 2.35), which has become the “gold standard” definition<sup>[4,6,7]</sup>. Since then, there have been many publications evaluating POAF’s impact on surgical patients’ clinical outcomes and resource utilization. Despite the initial VA and STS POAF definitional uniformity, there has been a growing divergence across the POAF definitions used by surgical society databases as well as the subsequent guidelines promulgated. Comparing the cardiothoracic versus non-cardiothoracic surgical society-based publications, this study documents the tremendous diversity of POAF definitions for the first time.

## METHODS

For this qualitative content analysis, ten professional societies’ cardiac interventional database definitions and clinical guideline recommendations were analyzed. Societies were classified into procedural versus medical, based upon their specialization as listed below.

Cardiothoracic Interventional Societies (CT societies)

1. Society of Thoracic Surgeons (STS)<sup>[6]</sup>
2. American Association for Thoracic Surgery (AATS)<sup>[8]</sup>
3. Society for Cardiovascular Angiography and Interventions (SCAI)<sup>[9]</sup>



**Figure 1.** Hierarchical representation of our exclusion criteria for our article selection process. 71 w/ POAF definition in the highlighted box are the articles that were used in our analysis.

#### 4. American College of Surgeons (ACS) NSQIP<sup>[10]</sup>

All other Interventions (non-CT)

#### 5. American College of Cardiology (ACC)<sup>[11]</sup>

#### 6. American Heart Association (AHA)<sup>[11]</sup>

#### 7. Heart Rhythm Society (HRS)<sup>[11,12]</sup>

#### 8. American College of Chest Physicians (ACCP)<sup>[2,13]</sup>

#### 9. Heart Failure Society of America (HFSA)

#### 10. European Society of Cardiology (ESC)<sup>[1]</sup>

Other than the ESC [which published this guideline in collaboration with several listed United States (US)-based societies], the focus was placed on US-based professional society guidelines and database definitions. The latest guidelines and database definitions were identified for each society as of July 2021. All Society-related manuscripts were found using a comprehensive literature search by analyzing all publications since the VA's definition of POAF was first published in 1991. Additionally, a thorough Mesh search (completed as of May 28, 2021) included the following literature review search strategy:

((("atrial fibrillation"[MeSH Terms]) OR ("atrial flutter"[MeSH Terms])) AND ((("cardiac surgical procedures"[MeSH Terms]) or ("cardiology"[MeSH Terms]) or ("cardiac catheterization"[MeSH Terms]))) and ("definition" or "defined"))

This search resulted in 340 articles which were thoroughly analyzed for inclusion of working and stated definition for POAF. [Figure 1] provides an overview of the process of inclusion, but only 21% ( $n = 71$ ) of these articles contained any POAF definition.

Qualitative content analysis was used to classify: (1) part I - all professional society-based POAF definitions; and (2) part II - all professional society-based POAF guideline recommendations; whenever possible, sub-component categories were developed to identify emerging themes.

For part I, the published POAF definitions from the 71 key reference manuscripts were compared to the professional society based POAF definitional components; these include the six characteristics associated with a POAF definition listed below (see [Tables 1-3](#)).

1. POAF electrocardiogram findings
2. POAF episode duration
3. Timing of the first POAF observation
4. POAF-related symptoms
5. General POAF definitions
  - (1) New-onset
  - (2) Early-onset
  - (3) Late-onset
  - (4) Silent
  - (5) Recurrent
  - (6) Treatment
6. Inclusivity

Evaluating these six POAF definitional characteristics, the ten professional societies' POAF definitions were carefully analyzed (see [Table 4](#)).

For these same professional societies, their cardiac interventional guidelines were evaluated see [[Table 4](#)] according to the following three categories: POAF risk assessments, POAF prevention guidelines, and POAF management guidelines (see [Tables 5-7](#)).

## RESULTS

### Part I - POAF definitional components

Of the ten professional societies analyzed 50% ( $n = 5$ ) did not define POAF. [Table 1](#) presents the results of POAF definition characteristics by society. Not unexpectedly, of the 4 CT societies included 75% ( $n = 3$ ) defined POAF in contrast to only 33% of non-CT societies.

**Table 1. POAF characteristics**

Characteristics - subcomponents		STS	AATS	AHA ACC & HRS	ACS	SCAI	ACCP	HFSA	ESC	Count
<b>EKG finding</b>	Absence of P waves		*		*		*			3
	Irregular RR intervals		*		*		*			3
<b>Episode duration</b>	< 30 s		*							1
	> 30 s		*							1
	> 1 h		*							1
<b>First observation timing</b>	New onset POAF: < 48 h		*							1
	Persistent POAF: > 48 h		*							1
<b>Symptoms</b>	Severe hypotension		*		*					2
	Acute MI		*							1
	Ischemia		*							1
	Pulmonary edema/HF		*		*					2
	Chest pain				*					1
	Syncope				*					1
	Asymptomatic				*					1
<b>General Def.</b>	Clinically significant POAF: requires rhythm control, anti-coagulation, and/or extends hospitalization		*							1
	New-onset POAF: working diagnosis in a patient w/o history of AF								*	1
	POAF definition: atrial fibrillation requiring treatment	*								1
<b>Inclusivity</b>	Restrictive		*		*				*	3
	Inclusive		*				*			2
		3	11	0	8	0	2	0	2	

POAF definitions among ten professional medical societies with “\*” designating inclusion of criteria. Rows and columns are tallied up. The table provided is not meant to be an exhaustive set of definitions provided by the respective societies to account for training manuals or other such material not available to the public<sup>[1,2,6,8-13]</sup>. POAF: Post-operative atrial fibrillation; STS: Society of Thoracic Surgeons; AATS: American Association for Thoracic Surgery; AHA: American Heart Association; ACC: American College of Cardiology; HRS: Heart Rhythm Society; ACS: American College of Surgeons; SCAI: Society for Cardiovascular Angiography and Interventions; ACCP: American College of Chest Physicians; HFSA: Heart Failure Society of America; ESC: European Society of Cardiology; HF: heart failure; EKG: Electrocardiogram; RR: RR the time between two consecutive QRS signals’ R waves.

The STS’s POAF definition described in [Table 1] was updated in 2014. Prior to this update, its definition was “atrial fibrillation requiring treatment”, and this was the most frequently referenced by independent manuscripts ( $n = 13/71$ ; 18%).

Tables 2 and 3 classify the POAF definitional characteristics from the 51 independent manuscripts. Specific electrocardiogram characteristics were most frequently mentioned at 86% ( $n = 44$ ) along with new-onset POAF (53%;  $n = 27$ ). All but one publication stated that the clinical significance of a POAF episode should be less than or equal to one hour; thus, there was the most uniformity in this PAOF component. While not clearly a majority, the largest consensus among publications ( $n = 22/71$ ; 31%) considered at least 30 s to be clinically significant POAF; this was a point also shared by professional societies where 2 of the 3 that noted episode duration criteria also used 30 s as their standard.

Based on this detailed review, great variability was observed across all three tables. In [Table 1] 76% ( $n = 13/17$ ) of the criteria used was used by only one society. In [Table 2] 71% ( $n = 20/28$ ) of the criteria was used by only one independent manuscript and in [Table 3] it was 42% ( $n = 8/19$ ). Of all of the criteria used to compare societies and independent manuscripts, the criteria for both electrocardiogram findings and episode duration were the only categories that reached a consensus (i.e., reported above 50%).

**Table 2. Timing, nature, and treatment**

	<b>Criteria - subcomponents</b>	<b>Number of publications</b>
<b>New-onset</b>	Continuous AF at any time before discharge	9
	Occurring during the procedure or within 30 days post-procedure	6
	Continuous AF at any time postoperatively	4
	Occurring during the procedure or within 30 days post-procedure, w/o history of previous AF	2
	Continuous AF of any duration at any time postoperatively	2
	Any documented AF in the first 7 days following surgery, w/o history of previous AF	1
	Any episodes that are brief, paroxysmal, and asymptomatic	1
	ICD-9 code discharge diagnosis code of AF, not present before admission	1
	Occurring during the procedure or within 3 days post-procedure	1
<b>Early onset</b>	Occurring in the surgical department	2
	Any AF episode diagnosed by a physician during the hospital stay	1
	ICD-9 code of 427.31 or ICD-10 code (I48.0, I48.1, I48.2, or I48.91) within admission or post-procedure	1
	Any documented AF in the first 6 days following surgery	1
	Any documented AF in the first 7 days following surgery	1
	Occurring during the procedure or within 14 days post-procedure	1
	Occurring during the procedure or within 9 days post-procedure	1
Occurring during the procedure or within 10 days post-procedure	1	
<b>Late-onset</b>	Occurring 3 months after the procedure	1
	Occurring during the rehabilitation period	1
	Occurring during rehabilitation period and within 20 ± 5 days	1
	(Transplant): occurring after discharge, minimum 14 days post-procedure, w/o history of previous AF	1
	(Transplant): occurring after discharge, minimum 9 days post-transplant, w/o history of previous AF	1
<b>Silent</b>	Post-procedure, only detected by continuous ECG for pts w/o history of previous AF	1
	Within 7 days post-procedure, only detected by Holter for pts w/o history of previous AF	1
<b>Recurrent</b>	POAF recurrence: continuous AF at any time during or after the operation	3
<b>Treatment</b>	AF requiring treatment	13
	Within 48 h post-procedure, confirmed by ECG, resulting in the need for intervention	1
	Any documented AF in the first 7 days following surgery and requiring treatment	1

POAF general definitions comprised of 54 publications broken down into different criteria along with the number of publications mentioning a specific subcomponent. One publication may mention more than one subcomponent, but each subcomponent is composed of different publications. The time frame for this table spans from 2001-2020<sup>[3,15,19-70]</sup>.

Between societies and independent manuscripts, the most variability was seen between first POAF observation timing and diversity of general definitions with only 24% ( $n = 8/33$ ) of this criteria's subcomponents in agreement.

## Part II - guideline recommendations for POAF patient management

Across the ten professional societies guidelines, only eight included one or more management strategies for POAF classified based on the three listed strategies. Of these eight societies, three did not independently define postoperative atrial fibrillation but referred to another published atrial fibrillation definition. Five societies provided risk assessment guidelines [Table 6], seven societies published POAF prevention guidelines [Table 5], and all eight societies provided POAF management guidelines [Table 7].

In evaluating POAF risk, eight risk characteristics were commonly identified (> 50% consensus); all of these risk factors were viewed as non-modifiable, including preoperative atrial arrhythmias, valvular disease,

**Table 3. POAF imaging and duration**

	Criteria - subcomponents	Number of publications
<b>EKG finding</b>	Irregular RR intervals	20
	Absence of P waves	17
	Fluctuating baseline	4
	No consistent P waves before QRS	3
<b>Episode duration</b>	> 30 s	22
	> 5 min	14
	> 10 min	4
	> 15 min	3
	> 30 min	3
	> 1 min	2
	> 60 min	2
	> 10 s	1
	> 2 min	1
	Several minutes	1
	< 5 min	1
	> 6 min	1
	> 10 min	1
	< 60 min	1
	> 12 h	1

Criteria used to define POAF from 56 publications. These criteria are broken down into subcomponents along with the number of publications mentioning a specific subcomponent. One publication may mention more than one subcomponent, but each subcomponent is composed of different publications. The time frame for this table spans from 1995-2020<sup>[19-21,23-25,27-34,36,38-43,45-51,54-56,60,62-64,66,67,70-89]</sup>.

congestive heart failure, pericarditis, advancing age, male gender, and chronic lung disease. Advanced age had the greatest level (75%) of consensus among societies; advanced age as a risk for POAF has been identified by the literature<sup>[14]</sup>. Three thoracic surgery procedures that drew consensus between STS and AATS and identified a high incidence of POAF (> 15%) were pneumonectomy, pleurectomy, and lung transplantation. As a modifiable risk factor, HTN was mentioned but only rarely.

Across the eight prophylactic guidelines evaluated, the greatest level of consensus was found for the use of B-blockers ( $n = 5$  society-based guidelines) and amiodarone ( $n = 6$  society-based guidelines). Unlike the risk assessment guidelines, 68% ( $n = 17/25$ ) of the prophylactic recommendations were provided by procedural societies. Between these two procedural societies, AATS & STS, though only two were jointly recommended, “Avoid B-blocker withdrawal” and “Magnesium supplementation”.

Management guidelines were similarly reported (65%;  $n = 42/64$ ) primarily by procedural societies. Agreement was seen broadly among categories used. Eight societies provided guidelines and of these, eight provided guidance for anticoagulation, six provided guidance to ensure hemodynamic stability, six provided guidance for the sub-group of hemodynamic unstable POAF patients, five for all POAF patients, five for rhythm control POAF patients, and two for rate control POAF patients. These categories once expanded upon [Table 6] showed 58 recommendations of which only five were used by more than one society ( $n = 5/58$ ; 8%).

## DISCUSSION

This literature review summarized the guidelines and guideline key references evaluated. The purpose of this review was to describe the current POAF landscape. Through careful examination of definitions, risks,

**Table 4. Professional society POAF-related guidelines**

	Criteria - subpopulation	STS	AATS	ACC AHA & ESC	ACS	SCAI	ACCP	HFSA	ESC	Count
<b>Risks</b>	Have guidelines	*	*	*	*		*		*	6
	Non-clinical risk factors*		*	*	*					3
	Clinical risk factors*		*							1
<b>Prevention</b>	All patients*	*	*	*					*	4
	Higher risk patients*		*	*			*			3
<b>Management</b>	All patients*		*	*	*					3
	Anticoagulation*	*	*	*	*		*		*	6
	Hemodynamically stable*	*	*	*					*	4
	Hemodynamically unstable*	*	*	*					*	4
	Rate control*	*	*							2
	Rhythm control*	*	*	*						3
	EF < 45%					*				1
	EF > 45%					*				1
	Medical		*							1
	EP catheterization		*							1
	Surgical treatment		*							1
	Non-pharmacologic		*							1
	Post discharge		*							1
		7	15	9	6	0	3	0	5	

POAF guidelines of the ten professional societies with “\*” designating inclusion of criteria. Rows and columns are tallied up. These are broken down by risks, prevention, or management. These three criteria are further divided into a patient sub-population; criteria containing an asterisk (\*) are further expanded upon in [Tables 5-7](#) due to their inclusion in more than one society<sup>[8,10,90-93]</sup>. POAF: Post-operative atrial fibrillation; STS: Society of Thoracic Surgeons; AATS: American Association for Thoracic Surgery; AHA: American Heart Association; ACC: American College of Cardiology; HRS: Heart Rhythm Society; ACS: American College of Surgeons; SCAI: Society for Cardiovascular Angiography and Interventions; ACCP: American College of Chest Physicians; HFSA: Heart Failure Society of America; ESC: European Society of Cardiology; EF: Ejection fraction; EP: Electrophysiology procedure.

prevention, and management among both professional societies and literature, there is considerable evidence showing the extensive heterogeneity in defining and managing this POAF condition.

Comparing the POAF definitional components, an outstanding question is how can a POAF definition be constructed optimally? Balancing definitional sensitivity and specificity is crucial. When evaluating the STS and AATS POAF definitions, it is clear that these two societies define POAF very differently.

- STS definition: “POAF is defined as atrial fibrillation over one hour or requiring treatment”.

- AATS definition: “POAF is defined as an absence of P waves and irregular RR intervals with episodes lasting at least 30 s or the length of the EKG strip (if less than 30 s). New-onset is defined as lasting < 48 h and persistent > 48 h. Symptoms usually include severe hypotension, acute myocardial ischemia, ischemia, and pulmonary edema/heart failure. Clinically significant PAOF requires rhythm control, anti-coagulation, and/or extends hospitalization<sup>[8]</sup>”.

It can be argued that AATS’s definition, which has many layers, is in comparison to STS’s definition more restrictive in nature. This pull and tug of inclusivity and restrictiveness have consequences when attempting to capture the true incidence of clinically relevant POAF.

**Table 5. POAF prevention guideline characteristics**

		Subpopulation - subcomponents	STS	AATS	ACC AHA & ESC	ACS	SCAI	ACCP	HFSA	ESC	Count
<b>All patients</b>	Class I	Avoid B-blocker withdrawal	*	*							2
		Treat pts undergoing cardiac surgery with prophylactic oral B-Blocker			*					*	2
	Class IIa	Diltiazem is reasonable in most patients undergoing major pulmonary resection who are not on B-blocker already	*								1
		Administer amiodarone prophylactically to cardiac surgery	*		*					*	3
	Class IIb	Treat pts undergoing cardiac surgery with prophylactic oral B-Blocker	*								1
		Magnesium supplementation when Mg low or suspected body Mg low	*	*							2
	Class III	Digoxin is not recommended for prophylaxis		*							1
		Amiodarone is not recommended for patients undergoing pneumonectomy	*								1
		Flecainide is not recommended for prophylaxis	*								1
		Digitalis is not recommended for prophylaxis	*								1
	PVI is not recommended for the prevention of POAF if no previous AF history		*							1	
<b>Higher risk</b>	Class I	Chronic AF whom it is thought to continue post-operatively, anticoagulation is recommended						*			1
	Class IIa	Administer amiodarone prophylactically to cardiac surgery			*						1
		Administer diltiazem prophylactically to POAF pts not taking B-Blocker		*							1
		Administer amiodarone prophylactically to pulmonary resection		*							1
	Class IIb	Administer sotalol prophylactically to cardiac surgery			*						1
		Administer IV Amiodarone prophylactically to esophagectomy		*							1
		Administration of colchicine may be considered postoperatively			*						1
		Administer Atorvastatin prophylactically in higher risk thoracic surgical procedures		*							1
		LAA excision during left lung surgery for pts w/ previous AF History		*							1
			8	9	5	0	0	1	0	2	

POAF prevention guidelines between different societies with "\*" designating inclusion of criteria. Rows and columns are tallied up. Guidelines are broken down by the subpopulation (all patients or higher risk) and then by the class, each recommendation falls under [8,10,91-93]. POAF: Post-operative atrial fibrillation; STS: Society of Thoracic Surgeons; AATS: American Association for Thoracic Surgery; AHA: American Heart Association; ACC: American College of Cardiology; HRS: Heart Rhythm Society; ACS: American College of Surgeons; SCAI: Society for Cardiovascular Angiography and Interventions; ACCP: American College of Chest Physicians; HFSA: Heart Failure Society of America; ESC: European Society of Cardiology; LAA: POAF prevention guidelines between different societies; PVI: Pulmonary vein isolation.

Filardo et al.<sup>[15]</sup> provided a lens into how studies could be conducted to measure if a definition is truly capturing this data. It used the pre-2014 STS definition, "atrial fibrillation requiring treatment" and estimated that up to 3.6% of patients post-coronary artery bypass graft every year are not identified to have clinically relevant POAF<sup>[15]</sup>. This begs the question if the new STS definition improves upon this estimation and also if AATS (by approaching their definition with more "layers") is less inclusive.



Procedures	Risk Category	Procedure	*	*	*	*	*	*	*		
Low risk (< 5% incidence)		Flexible bronchoscopy w/ or w/o biopsy	*						1		
		Photodynamic therapy	*						1		
		Tracheal stenting	*						1		
		Placement of thoracostomy tube	*						1		
		Pleuroscopy, pleurodesis, decortication	*						1		
		Tracheostomy	*						1		
		Rigid bronchoscopy	*						1		
		Mediastinoscopy	*						1		
		Thoracoscopic lobectomy	*						1		
		Thoracoscopic wedge resection	*						1		
		Bronchoscopic laser surgery	*						1		
		Esophagoscopy/PEG/esophageal dilation or stenting	*						1		
		Intermediate risk (5%-15% incidence)		Thoracoscopic sympathectomy	*						1
				Segmentectomy	*						1
Laparoscopic Nissen fundoplication/myotomy	*								1		
Zenker diverticulectomy	*								1		
High risk (> 15% incidence)		Resection of anterior mediastinal mass	*						1		
		Thoracoscopic lobectomy	*						1		
		Open thoracotomy for lobectomy	*						1		
		Tracheal resection and reconstruction/carinal resection	*						1		
		Pneumonectomy	*	*					2		
		Pleurectomy	*	*					2		
		Volume reduction/bullectomy	*						1		
		Bronchopleural fistula repair	*						1		
		Clagett window	*						1		
		Lung transplantation	*	*					2		
Esophagectomy	*						1				
Pericardial window	*						1				
			14	43	12		10	0	0	0	0

POAF risk factors between ten professional societies with "\*" designating inclusion of criteria. Rows and columns are tallied up <sup>[8,10,91-93]</sup>. POAF: Post-operative atrial fibrillation; STS: Society of Thoracic Surgeons; AATS: American Association for Thoracic Surgery; AHA: American Heart Association; ACC: American College of Cardiology; HRS: Heart Rhythm Society; ACS: American College of Surgeons; SCAI: Society for Cardiovascular Angiography and Interventions; ACCP: American College of Chest Physicians; HFSA: Heart Failure Society of America; ESC: European Society of Cardiology; HF: heart failure; PEG: Percutaneous endoscopic gastrostomy.

In addition to correctly estimating the incidence of clinically relevant POAF, a universal definition will be critically important to facilitate future POAF research. Without POAF definitional consensus, researchers are not able to compare different POAF-related study conclusions as to the impact of POAF on subsequent morbidity, mortality, and cost. Furthermore, it will be challenging to compare the cost-effectiveness of POAF patient management<sup>[15]</sup>.

It is of great importance to place this responsibility on the correct groups. Will independent researchers come up with the needed clinical evidence to create such a universal definition or should professional societies take the mantle? Within professional societies, it is also important to note the gap of potential priorities for CT societies vs. non-CT societies. Earlier we noted a large discrepancy where 75% of CT societies vs. 33% of non-CT societies defined POAF. This could highlight potential roadblocks to which society might be better positioned to provide the scientific community with a proper universal POAF definition.

Currently, among most literature, *advanced age* is nearly universally an agreed upon POAF risk factor; yet [Table 6] displays over 60 factors that have the potential to further stratify patients into “at risk of POAF” sub-groups<sup>[14]</sup>. Creating POAF risk scores will require both a uniform POAF definition as well as a uniform consensus as to the other factors influencing POAF incidence. A POAF risk score would be of great assistance to clinicians to identify “at risk of POAF” patients before procedures. A risk score system based upon clinical evidence such as the CHA<sub>2</sub>DS<sub>2</sub>-VASc risk score used for atrial fibrillation patients and their risk of developing a stroke should now be a future goal for the evolving POAF field.

The aggregation of most current prevention and management guidelines into [Tables 5-7] is to serve as an aid for physicians and future studies. Areas of consensus show where future clinical trials could focus their attention such as the prophylactic role of B-blocker and amiodarone use. Management guidelines show more variability than prevention guidelines with only 8% of recommendations advocated by more than one society.

Such a disparity correlates with the current landscape of POAF. Not only is the occurrence of POAF as high as 50% in cardiac procedures, but its recurrence once treated is over 50% over a two-year period<sup>[1,2,16]</sup>. This shows that a proven system for treatment and prevention has not been achieved. It would be of value if a study could show the incidence rate over time of POAF and its correlation to new management/prevention guidelines.

Many other contributing factors should be considered when looking at such a high incidence rate of POAF. One of which is a serious lack of high-quality, randomized controlled trials<sup>[16]</sup>. This could stem from a refusal of acknowledgment or visibility among professional societies. For example, among the medical societies, the 2020 update to the ESC guidelines for atrial fibrillation mentions POAF in only 2 of its 126 pages, and the updated 2014 AHA/ACC/HRS guidelines for atrial fibrillation mention POAF in only 2 of its 76 pages. Among the procedural societies, STS and AATS, there has not been an update to POAF guidelines for 9 and 6 years, respectively.

The variability among definitions also creates large challenges when comparing different clinical studies. One manuscript might consider POAF lasting > 30 s, while another more restrictive study could propose to look at POAF lasting > 5 min. Regardless of the specific variability, this diversity in POAF definitions hampers meta-studies that could evaluate treatment options.

**Table 7. POAF treatments: level of evidence**

		Characteristics - subcomponents	STS	AATS	ACC AHA & ESC	ACS	SCAI	ACCP	HFSA	ESC	Count	
<b>All patients</b>	Class I	Reduce or stop catecholaminergic inotropic agents		*							1	
		Optimize fluids and maintain normal electrolyte levels		*							1	
		Evaluate/treat any possible triggering factors		*		*					2	
		A non-dihydropyridine CCB is recommended when beta-blockers are inadequate in achieving rate control				*					1	
		Maintain Mg > 2 mg/dL					*				1	
		Maintain K > 4 mmol/L					*				1	
		Treat w/ beta-blocker unless contraindicated				*					1	
		Restart home beta-blocker (if applicable)					*				1	
		Check TSH levels					*				1	
	Class IIa	Synchronized electrical cardioversion or Ibutilide as recommended for nonsurgical pts			*						1	
<b>Hemodynamically unstable</b>	Class I	Synchronized electrical cardioversion within 48 h and before anticoagulation		*							1	
		Synchronized electrical cardioversion after 48 h and w/ anticoagulation continued for 4 weeks		*							1	
		Synchronized electrical cardioversion	*						*		2	
	Class IIa	If cardioversion is unsuccessful initiate rate and rhythm control w/ IV esmolol, diltiazem, digoxin, or amiodarone while preparing repeat cardioversion		*								1
		Treat recurrent or refractory POAF through antiarrhythmic medications as recommended by pts w/ CAD who develop AF				*						1
		Should initially manage w/ rate control and anticoagulation								*		1
		Cardiology consultation may be useful		*								1
<b>Hemodynamically stable</b>	Class I	Pts w/ hemodynamically stable and symptomatically acceptable POAF should receive a rate control lasting approximately 24 h	*								1	
		Pts w/ hemodynamically stable but symptomatically intolerable AF should be chemically or electrically cardioverted	*								1	
	Class IIa	Manage w/ rate control strategy		*		*						2
		Pharmacologic or cardioversion is reasonable in pts who have recurrent or refractory POAF are uncontrolled v. rates or medication symptoms		*								1
		Pts w/ hemodynamically stable, continuous, or recurrent, POAF ongoing > 24 h after initiation of rate control, it is reasonable to attempt chemical cardioversion	*									1
		Pharmacologic or electrical cardioversion is reasonable in pts who are nearing 48 h new-onset POAF that have contraindications for anticoagulation		*								1
		Antiarrhythmic medication should be considered to restore sinus rhythm				*				*		2
		Pts w/ hemodynamically stable, continuous, or recurrent, POAF ongoing after chemical cardioversion may be considered for an electrical cardioversion	*									1
		IV Vernakalant may be considered for cardioversion w/o severe HF, HTN, or severe								*		1

		structural heart disease			
<b>Anticoagulation</b>	Class I	For POAF < 48 h, anticoagulation should be based on CHA2DS2-VASc risk score for the pt	*		1
		For POAF > 48 h, antithrombotic medications are recommended as recommended to non-surgical pts	*		1
		Consider anticoagulation if AF > 48 h		*	1
		Administer antithrombotic medication as recommended for nonsurgical pts		*	1
	Class IIa	For pts w/ 2+ risk factors w/ POAF > 48 h, anticoagulation is reasonable if not contraindicated	*		1
		For pts w/ < 2 risk factors and not suitable for warfarin w/ PAOF > 48 h, aspirin (325 mg), is reasonable if not contraindicated	*		1
		It is reasonable to administer antithrombotic medication in pts, as advised for nonsurgical pts		*	1
		Long term anticoagulation should be considered for pts at risk for stroke			* 1
		NOACs (dabigatran, rivaroxaban, apixaban) are reasonable as an alternative to warfarin for pts w/o prosthetic heart valve, valve disease, and or renal impairment or risk of gastrointestinal bleeding	*		1
		It is reasonable to continue anticoagulation therapy for 4 weeks after the return of sinus rhythm	*		1
Class III	NOACs should be avoided for pts at risk for serious bleeding	*		1	
	In high-risk POAF (history of stroke or TIA), heparin should be considered		*	1	
	Recommended to continue anticoagulation therapy 30 days after return to sinus rhythm		*	1	
<b>Rate</b>	Class I	IV of B-blockers or Non-dihydropyridine CCB for patients w/ rapid ventricular response	*		1
		Caution should be used with pts w/ hypotension, LV dysfunction, or HF	*		1
		A selective B1-blocking agent is recommended as the initial drug for rate control in the absence of moderate-severe chronic obstructive pulmonary disease or active bronchospasm	*		1
		Diltiazem should be the first agent used in the presence of moderate-severe chronic obstructive pulmonary disease or active bronchospasm.	*		1
	Class IIa	Combo of AV nodal blocking agents: B-blockers, non-dihydropyridine CCB, or digoxin can be useful if single-agent fails	*		1
		For pts, w/ hypotension, HF, or LV dysfunction IV amiodarone can be useful	*		1
	Class IIb	For pts, w/ hypotension, HF, or LV dysfunction IV digoxin can be useful	*		1
		Class III	For pts, w/ preexcitation and POAF use of AV nodal blocking agents: beta-blockers, IV amiodarone, non-dihydropyridine CCB, or digoxin should be avoided	*	
	Digoxin as a single agent should not be used for rate control, although it may be effective in combination with a B1-blocker or diltiazem.		*		1
	<b>Rhythm</b>	Class IIa	IV Amiodarone is useful for pharmacologic cardioversion of POAF	*	
It is reasonable to restore sinus rhythm pharmacologically w/ ibutilide or cardioversion				*	1

	Amiodarone, sotalol, flecainide, propafenone, or dofetilide can be useful to maintain sinus rhythm	*								1
	When chemical cardioversion is employed in the setting of continuous or recurrent POAF, the most reasonable initial drugs are IV followed by oral amiodarone or oral flecainide	*								1
Class IIb	Flecainide or propafenone may be considered for pharmacologic cardioversion of POAF if the pt has had no previous history of MI, CAD, LV dysfunction, LV hypertrophy, or valvular disease considered moderate or greater	*								1
	IV ibutilide or procainamide may be considered in pts w/ structural heart disease w/o hypotension or congestive HF	*								1
	IV ibutilide or procainamide may be considered for pts w/ an accessory pathway	*								1
Class III	Amiodarone is not recommended in pts who are mechanically ventilated, who have undergone pneumonectomy, or who have substantial pre-existing lung disease	*								1
	Flecainide should not be used in pts with any history of structural cardiac disease, including ventricular hypertrophy, systolic dysfunction, or any valve or coronary disease	*	*							2
	Dronedarone should not be used for the treatment of POAF in pts w/ HF	*								1
			13	29	9	6	0	2	0	5

POAF management guidelines between different societies with “\*” designating inclusion of criteria. Rows and columns are tallied up. Guidelines are broken down by the subpopulation and then by the class, each recommendation falls under <sup>[8,10,11,89-91]</sup>. POAF: Post-operative atrial fibrillation; STS: Society of Thoracic Surgeons; AATS: American Association for Thoracic Surgery; AHA: American Heart Association; ACC: American College of Cardiology; HRS: Heart Rhythm Society; ACS: American College of Surgeons; SCAI: Society for Cardiovascular Angiography and Interventions; ACCP: American College of Chest Physicians; HFSA: Heart Failure Society of America; ESC: European Society of Cardiology; HF: heart failure; MI: POAF management guidelines between different societies with; CAD: Coronary artery disease; LV: Left ventricle; CCB: Calcium channel blocker; NOACs: Novel oral anticoagulants (e.g., direct thrombin inhibitors and anti-Factor Xa agents).

Based on the results found on POAF variability, we propose the following loose definition to be used as a placeholder until future evidence-based definitions are discovered. This definition is based on consensus from independent publications and professional societies: new-onset AF should be defined based on ECG findings longer than 30 s. Treatment or symptoms are confirmatory but do not provide adequate evidence of clinical new-onset AF.

It is also crucial to arrive at such a conclusion to use our current surgical databases to their highest potential. Currently, STS has the world’s gold standard clinical outcomes registry in adult cardiac surgery. Since its inception, more than 100 publications have utilized its information, and it currently contains more than 6.5 million cardiac surgery procedure records<sup>[6,17]</sup>.

At this time, AATS is creating a new cardiac surgery database which may likely soon achieve the same STS level of importance to the scientific community<sup>[18]</sup>. This highlights how crucial it is that the data physicians’ daily input be of the highest quality and the greatest consistency. As the scientific community works to find the true impact that POAF has on patients, it must use data that is consistent and based upon clinical significance.

In summary, POAF has not been consistently defined by all professional societies as an important post-procedural complication. Instead of being classified uniformly as major morbidity, POAF is frequently considered a surgical nuisance; however, it should be viewed as a serious morbid complication that can lead

to stroke and other emboli complications as well as congestive heart failure. Building upon Filardo's initial study, therefore, additional POAF research now appears warranted. In order to optimize the future effectiveness and efficiency of cardiac surgical care, a clinically relevant POAF definition needs to be established<sup>[15]</sup>. Moreover, high-quality, randomized, controlled clinical trials are needed to evaluate the current POAF prevention and management strategies. Although atrial fibrillation medication-based trials have been completed, the lack of visibility and urgency towards finding options to address new-onset POAF has stalled. Hopefully, this review highlights the significance of POAF to future cardiac surgical quality improvement efforts, building an urgency to establish a POAF definitional consensus to reduce the prevalence and burden of this important condition.

## DECLARATIONS

### Authors' contributions

Made substantial contributions to this study's conceptualization and qualitative design: Pardo D, Rove JY, Grover FL, Shroyer AL

Coordinated the literature review, captured the study data, performed the preliminary analysis, and provided summary reports describing this study's findings: Pardo D

Verified a sampling of the data captured and guided the analyses performed: Shroyer AL

Assisted with data report interpretation: Rove JY, Grover FL

Prepared the first manuscript draft: Pardo D, Shroyer AL

Revised the manuscript substantively and provided final manuscript approval: Pardo D, Rove JY, Grover FL, Shroyer AL

### Availability of data and materials

Not applicable.

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All authors declared that there are no conflicts of interest.

### Ethical approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

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