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ORIGINAL RESEARCH

Differences in Postoperative Atrial Fibrillation Incidence and Outcomes After Cardiac Surgery According to Assessment Method and Definition: A Systematic Review and Meta-Analysis

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BACKGROUND: Postoperative atrial fibrillation (POAF) is the most frequent complication of cardiac surgery. Despite clinical and economic implications, ample variability in POAF assessment method and definition exist across studies. We performed a study-level meta-analysis to evaluate the influence of POAF assessment method and definition on its incidence and association with clinical outcomes.

METHODS AND RESULTS: A systematic literature search was conducted to identify studies comparing the outcomes of patients with and without POAF after cardiac surgery that also reported POAF assessment method. The primary outcome was POAF incidence. The secondary outcomes were in-hospital mortality, stroke, intensive care unit length of stay, and postoperative length of stay. Fifty-nine studies totaling 197 774 patients were included. POAF cumulative incidence was 26% (range: 7.3%–53.1%). There were no differences in POAF incidence among assessment methods (27%, [range: 7.3%–53.1%] for continuous telemetry, 27% [range: 7.9%–50%] for telemetry plus daily ECG, and 19% [range: 7.8%–42.4%] for daily ECG only; $P>0.05$ for all comparisons). No differences in in-hospital mortality, stroke, intensive care unit length of stay, and postoperative length of stay were found between assessment methods. No differences in POAF incidence or any other outcomes were found between POAF definitions. Continuous telemetry and telemetry plus daily ECG were associated with higher POAF incidence compared with daily ECG in studies including only patients undergoing isolated coronary artery bypass grafting.

CONCLUSIONS: POAF incidence after cardiac surgery remains high, and detection rates are variable among studies. POAF incidence and its association with adverse outcomes are not influenced by the assessment method and definition used, except in patients undergoing isolated coronary artery bypass grafting.

Key Words: assessment method ■ cardiac surgery ■ definition ■ incidence ■ postoperative atrial fibrillation

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CLINICAL PERSPECTIVE

What Is New?

- In this study-level meta-analysis, we found no difference in incidence of postoperative atrial fibrillation by assessment method, whether telemetry only, telemetry plus ECG, or ECG only were used, and there was also no difference in the incidence of postoperative atrial fibrillation irrespective of the definition used.

What Are the Clinical Implications?

- There was no difference among assessment methods in incidence of postoperative atrial fibrillation or the association of postoperative atrial fibrillation with adverse clinical outcomes.

Nonstandard Abbreviations and Acronyms

POAF	postoperative atrial fibrillation

Postoperative atrial fibrillation (POAF) is the most frequent complication of cardiac surgery, with an incidence ranging from 15% to 40%.[1] Often regarded as a transient event triggered by inflammation after surgery, POAF has been associated with worse clinical outcomes (including mortality, stroke, and heart failure)[2,3] and increased cost of care.[4,5] Despite the proven success of medical[6] and surgical[7] strategies for POAF prevention, a high proportion of patients remains affected, resulting in efforts to elucidate the pathophysiologic mechanisms of, and risk factors for, POAF as potential targets for intervention.

The term POAF generally refers to new-onset atrial fibrillation during the postoperative hospitalization period.[1,8,9] However, no consensus definition for POAF has been established by professional societies,[10,11] leading to marked heterogeneity in POAF definitions across studies. Some groups have reported POAF episodes regardless of duration or need for treatment,[12,13] others have used duration-based POAF definitions (with arbitrarily defined cutoffs to report the arrhythmia ranging from 30 seconds to 60 minutes),[14,15] and others have reported only those POAF episodes that required treatment or intervention.[16,17] In addition, there is variability in the POAF assessment methods employed across studies, ranging from monitoring with continuous telemetry during the whole postoperative hospitalization to the use of daily ECG only. The heterogeneity in POAF assessment method and definition opens questions on the interpretation and generalizability of published studies.

We performed a systematic review and meta-analysis to evaluate the incidence of POAF and its association with clinical outcomes according to the POAF assessment method and definition used in individual studies.

METHODS

The present review was registered in the National Institute for Health Research International Registry of Systematic Reviews (CRD42023399670). The article is compliant with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline.[18] Institutional review board approval was waived. Informed consent was not required.

Search Strategy

A comprehensive literature search was performed by a medical librarian (M.D.) to identify studies that compared outcomes of patients who developed POAF versus patients who did not after cardiac surgery. Searches were run on July 6, 2022 and updated on May 31, 2023 in the following databases: Ovid MEDLINE (ALL; 1946 to present), Ovid EMBASE (1974 to present), and The Cochrane Library (Wiley; 1992 to present). The complete search strategy for Ovid MEDLINE is available in Table S1.

Study Selection and Data Extraction

After deduplication, records were screened by 2 independent reviewers (L.H. and R.P.O.) using Microsoft Excel version 16.73. Any discrepancies were adjudicated by the senior author (M.G.). Titles and abstracts were reviewed against predefined inclusion and exclusion criteria. Studies were considered for inclusion if they compared outcomes of patients who developed POAF after noncongenital cardiac surgery versus patients who did not. Animal studies, abstracts, case reports, commentaries, editorials, expert opinions, conference presentations, and studies that did not report POAF assessment method were excluded. The full text of the selected articles was pulled for a second round of eligibility screening. The reference lists were also reviewed for relevant studies not captured by the original search. The methodological quality of the included studies was assessed by 2 reviewers (L.H. and R.P.O.) in 3 domains: (1) cohort selection and comparability, (2) reporting of POAF assessment method and POAF incidence, and (3) reporting of POAF definition. This assessment was based on the Newcastle-Ottawa Scale. Details of POAF definition in each study are provided in Table S2.

Two investigators (T.C. and R.P.O.) independently performed data extraction, and the accuracy was verified by the senior author (M.G.). The variables

included were study characteristics (publication year, institution, country of origin, study period, type of surgery, sample size, POAF definition, POAF incidence, and POAF assessment method), patients' demographic characteristics (age, sex, left ventricular ejection fraction, hypertension, diabetes, chronic obstructive pulmonary disease, prior cerebrovascular accident, prior myocardial infarction, preoperative use of beta blockers, prior cardiac surgery, and chronic kidney disease), in-hospital mortality, stroke, intensive care unit (ICU) length of stay (LOS) and postoperative LOS.

Outcomes

The primary outcome was POAF incidence according to the POAF assessment method used. Three different assessment methods were identified: (1) continuous telemetry until hospital discharge, (2) continuous telemetry during ICU stay followed by daily ECG while patients were in the regular ward, and (3) daily ECG only.

The secondary outcomes were in-hospital mortality, stroke, ICU LOS, and postoperative LOS according to the POAF assessment method used.

Secondary Analyses

In the secondary analyses, the primary and secondary outcomes were analyzed based on the definition of POAF used in individual studies: (1) intervention-based definition, which included only POAF episodes requiring treatment, and (2) nonintervention-based definition, which included POAF regardless of episode duration or need for treatment. Details of the assigned POAF definition category in each study are provided in Table 1.

Subgroup and Additional Analyses

A subgroup analysis for the primary outcome was performed in studies including only patients undergoing isolated coronary artery bypass grafting (CABG). An additional analysis looking at the trend in POAF incidence over the study period was also performed.

Statistical Analysis

Categorical variables were extracted as numbers and continuous variables were extracted as mean and SD.

For each assessment method, the incidence of POAF across studies was pooled as an overall proportion (overall number of events/total number of patients) using an inverse variance method, which takes into account the weight of each study relative to the study sample size. Both common and random effects estimates were reported. Ninety-five percent CIs were estimated using the Clopper–Pearson interval.

Subsequently, pooled proportions were compared between the different types of monitoring using a standard test for heterogeneity across the subgroup results, as previously described.[19] Similarly, categorical outcomes were compared by assessment methods.

The proportion of POAF across monitoring methods was also compared using chi-square test among the subgroups.

Trend in the postoperative incidence of POAF during the study years was investigated using the locally estimated scatterplot smoothing.

For continuous outcomes (ICU and postoperative LOS), the LOS across studies was pooled as an overall mean using an inverse variance method and subsequently compared using a test for subgroup differences.

Statistical heterogeneity was assessed with I^2, which describes the percentage of the variability in the effect estimates due to heterogeneity rather than sampling error. Low, moderate, and high heterogeneity were defined as $I^2 < 25\%$, 25% to 50%, and >50%, respectively.[20] Tau-squared using DerSimonian–Laird model was used to estimate the between-study variance.

Funnel plot and Egger's test were used to assess for publication bias graphically and quantitatively.

Univariable, random-effects meta-regression was used to explore the association between POAF incidence and the rigor of the assessment method used. Compared with the main analysis, which is based on pairwise comparisons, the meta-regression uses the monitoring methods as an ordinal, 3-level variable, where continuous telemetry until hospital discharge is considered more rigorous than telemetry during ICU stay followed by daily ECG in the regular ward, which is considered more rigorous than daily ECG only. Moreover, logistic regression with robust SE was performed for the association of POAF and categorical variables after reproducing the individual level data.

Statistical analyses were performed in R version 4.0.3 (R Foundation for Statistical Computing) using the package *meta*.

Data Availability

Data collected for the study will be made available by the corresponding author upon reasonable request after publication.

RESULTS

Study and Patient Characteristics

Among the 8974 identified (6212 screened) articles, a total of 59 studies published between 1993 and 2022 were included in the present analysis.[3–5,7,12–17,21–69] The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram outlining the study

Table 1. Characteristics of the Included Studies

Study, year	Institution or trial name	Country	Study period	Type of surgery	Total number of patients	Incidence of POAF	Assessment method	POAF definition category (duration, if applicable)
Creswell, 1993[21]	Washington University Medical Center	United States	1986–1991	Multiple	3983	34.6%	Telemetry	Not reported
Aranki, 1996[16]	Brigham and Women's Hospital	United States	1993–1994	CABG	570	33.2%	Telemetry	Intervention-based
Stamou, 2000[17]	Washington Hospital Center	United States	1987–1999	CABG	969	21.3%	Telemetry	Intervention-based
Tamis, 2000[22]	St. Luke's Hospital	United States	1992–1994	CABG	216	25.5%	Telemetry+ECG	Nonintervention-based (≥30 min)
Hakala, 2002[23]	Kuopio University Hospital	Finland	1992–1996	CABG	3676	31%	ECG	Not reported
Silva, 2004[24]	Institute of Cardiology of Rio Grande/Fundacion Universitaria de Cardiologia	Brazil	2002	Multiple	158	28.5%	Telemetry+ECG	Nonintervention-based (≥15 min)
Villareal, 2004[12]	Texas Heart Institute	United States	1993–1999	CABG	6475	15.4%	ECG	Nonintervention-based (any duration)
Kalavrouziotis, 2007[25]	Maritime Heart Center	Canada	1995–2003	CABG±AVR	7347	27.9%	Telemetry+ECG	Intervention-based
Mariscalco, 2007[26]	Umea University Hospital	Sweden	1994–2004	Multiple	8434	25.6%	Telemetry+ECG	Nonintervention-based (≥15 min)
Nisanoglu, 2007[13]	Turgut Ozal Medical Center	Turkey	2001–2005	CABG	426	21.4%	Telemetry+ECG	Nonintervention-based (any duration)
Mariscalco, 2008[27]	Varese University Hospital/Monizo Cardiology Center	Italy	2000–2005	CABG	1832	31.1%	Telemetry	Nonintervention-based (≥15 min)
Ahlsson, 2010[28]	Örebo University Hospital	Sweden	1999–2000	CABG	571	28.9%	Telemetry+ECG	Nonintervention-based (≥1 min)
Bramer, 2010[29]	Catharina Hospital	Netherlands	2003–2007	CABG	5098	22%	Telemetry+ECG	Nonintervention-based (≥30 min)
Shirzad, 2010[30]	Tehran Heart Center	Iran	2002–2008	Multiple	15 580	7.2%	Telemetry	Nonintervention-based (≥5 min)
Attaran, 2011[31]	Liverpool Heart and Chest Hospital	United Kingdom	1998–2009	Multiple	17 379	28.7%	ECG	Nonintervention-based (any duration)
Bramer, 2011[32]	Catharina Hospital	Netherlands	2003–2010	Mitral valve repair/replacement ± CABG±tricuspid valve repair/replacement	856	42.2%	Telemetry+ECG	Nonintervention-based (≥30 min)
Girerd, 2012[33]	Laval Hospital	Canada	2000–2007	CABG	6728	27.8%	Telemetry+ECG	Intervention-based
Helgadottir, 2012[34]	Landspitali Hospital	Iceland	2002–2006	CABG or AVR	744	43.8%	Telemetry+ECG	Nonintervention-based (≥5 min)

(*Continued*)

Table 1. Continued

Study, year	Institution or trial name	Country	Study period	Type of surgery	Total number of patients	Incidence of POAF	Assessment method	POAF definition category (duration, if applicable)
Saxena, 2012[35]	Australasian Society of Cardiac and Thoracic Surgeons Cardiac Surgery Database	Australia	2001–2009	CABG	19947	27.8%	Telemetry+ECG	Intervention-based
Horwich, 2013[36]	Queen Elizabeth II Health Sciences Centre	Canada	1995–2009	CABG	8058	27.5%	Telemetry	Intervention-based
O'neal, 2013[37]	East Carolina Heart Institute	United States	1992–2011	CABG	13165	22.1%	Telemetry	Intervention-based
Saxena, 2013[38]	Australasian Society of Cardiac and Thoracic Surgeons Cardiac Surgery Database	Australia	2001–2009	AVR	2065	35.1%	Telemetry+ECG	Intervention-based
Ivanovic, 2014[39]	Clinical Center of Serbia	Serbia	2006–2009	CABG	460	22.4%	Telemetry+ECG	Nonintervention-based (≥15 min)
Philip, 2014[40]	Cleveland Clinic	United States	1993–2005	CABG	5135	29%	Telemetry+ECG	Nonintervention-based (≥2 min)
Pivatto, 2014[41]	Cardiology Institute/ University Foundation of Cardiology	Brazil	2000–2011	AVR	348	32.8%	Telemetry+ECG	Nonintervention-based (any duration)
Weidinger, 2014[42]	University of Maryland	Austria and United States	2001–2010	CABG	384	15.4%	Telemetry	Intervention-based
Junior, 2015[43]	Santa Isabel Hospital	Brazil	2011–2013	CABG	230	16.1%	ECG	Not reported
Melduni, 2015[15]	Mayo Clinic	United States	2000–2005	Multiple	603	37.5%	Telemetry	Nonintervention-based (≥30 s)
Tsai, 2015[44]	Tri-Service General Hospital, National Defense Medical Center	Taiwan	2009–2012	CABG	266	47.4%	Telemetry+ECG	Intervention-based
Tulla, 2015[45]	Kuopio University Hospital	Finland	2000–2010	CABG	276	50%	Telemetry+ECG	Nonintervention-based (≥5 min)
Omer, 2016[46]	Michael E. DeBakey VA Medical Center	United States	2006–2013	CABG	1248	17.2%	Telemetry	Not reported
Sahin, 2016[47]	Kolan International Hospital	Turkey	2008–2012	CABG	149	36.9%	Telemetry+ECG	Not reported
Ismail, 2017[48]	King Faisal Specialist Hospital and Research Center	Saudi Arabia	2013–2015	CABG	252	33.3%	Telemetry	Intervention-based
Lee, 2017[49]	Severance Cardiovascular Hospital	Korea	2005–2011	CABG	1664	24.8%	Telemetry+ECG	Nonintervention-based (any duration)
Park, 2017[50]	Gachon University Gil Medical Center	Korea	1999–2010	Multiple	938	22.1	Telemetry+ECG	Nonintervention-based (≥1 min)

(*Continued*)

Table 1. Continued

Study, year	Institution or trial name	Country	Study period	Type of surgery	Total number of patients	Incidence of POAF	Assessment method	POAF definition category (duration, if applicable)
Swinkels, 2017[14]	St. Antonius Hospital, Academic Medical Center	Netherlands	1990–1994	AVR±CABG	569	42.4%	ECG	Nonintervention-based (>120 min)
Kosmidou, 2018[51]	Evaluation of XIENCE versus Coronary Artery Bypass Surgery for Effectiveness of Left Main Revascularization trial	International	2010–2014	CABG	893	18%	Telemetry+ECG	Nonintervention-based (≥30 s)
Schwann, 2018[52]	University of Toledo	United States	1994–2012	CABG±carotid reconstruction	8807	22.6%	Telemetry	Intervention-based
Almassi, 2019[5]	Randomized On/Off Bypass Trial	United States	2002–2008	CABG	2103	26.2%	Telemetry	Nonintervention-based (≥30 min)
Carter-storch, 2019[53]	Odense University Hospital	Denmark	2014–2016	AVR±CABG	96	53.1%	Telemetry	Nonintervention-based (any duration)
Filardo, 2019[54]	Baylor University Medical Center, The Heart Hospital at Baylor Plano, Emory University, Washington University	United States	2002–2010	CABG	9203	31.5%	Telemetry	Nonintervention-based (any duration)
Hernández-leiva, 2019[4]	Institute of Cardiology	Colombia	Not reported	Multiple	44	50%	Telemetry	Nonintervention-based (≥30 s)
Kato, 2019[55]	Sakakibara Heart Institute, Kishiwada Tokushukai Hospital, Lobe City Medical Center General Hospital, The Cardiovascular Institute, Fukuyama Cardiovascular Hospital, St. Luke's International Hospital, Kitano Hospital, Shizuoka Medical Center, Higashi Takarazuku Satoh Hospital, Sakakibara Heart Institute of Okayama	Japan	2015–2016	Multiple	302	21.9%	Telemetry	Nonintervention-based (≥5 min)
Benedetto, 2020[3]	Arterial Revascularization Trial	International	2004–2007	CABG	3023	24.3%	Telemetry+ECG	Nonintervention-based (≥30 s)
Cole, 2020[56]	Liverpool Heart and Chest Hospital	United Kingdom	2013–2018	Multiple	5588	24.8%	Telemetry+ECG	Not reported

(*Continued*)

Table 1. Continued

Study, year	Institution or trial name	Country	Study period	Type of surgery	Total number of patients	Incidence of POAF	Assessment method	POAF definition category (duration, if applicable)
Fragao, 2020[57]	University Of Porto	Portugal	2014–2015	AVR	379	42.2%	Telemetry+ECG	Nonintervention-based (≥30s)
Krishna, 2020[58]	Kasturba Medical College	India	2015	CABG	99	20.2%	ECG	Intervention-based
Malhotra, 2020[59]	Sanjay Gandhi Postgraduate Institute of Medical Sciences	India	2018–2019	CABG	263	9.1%	ECG	Not reported
Thoren, 2020[60]	Uppsala University Hospital	Sweden	1996–2012	CABG	7145	30.6%	Telemetry+ECG	Intervention-based
Fan, 2021[61]	Peking University People's Hospital	China	2012–2015	CABG	165	15.2%	Telemetry	Nonintervention-based (≥30s)
Gaudino, 2021[7]	Weill Cornell Medicine-New York Presbyterian Hospital	United States	2017–2021	Multiple	420	24.5%	Telemetry	Nonintervention-based (≥30s)
Hsu, 2021[62]	National Taiwan University Hospital	Taiwan	2007–2017	Multiple	6267	32.2%	Telemetry+ECG	Nonintervention-based (≥30s)
Lee, 2021[63]	Sejong General Hospital	Korea	2015–2017	CABG	507	18.5%	Telemetry	Not reported
Omar, 2021[64]	Cairo University Hospitals	Egypt	2019–2020	CABG	1000	7.8%	ECG	Nonintervention-based (≥30s)
Wang, 2021[65]	National University Heart Centre Singapore, National Heart Centre Singapore	Singapore	2008–2012	Multiple	2740	20.9%	Telemetry+ECG	Nonintervention-based (≥60 min)
Zhao, 2021[66]	Fuwai Hospital	China	2012–2019	Total arch repair	1271	32.3%	Telemetry	Nonintervention-based (≥5 min)
Musa, 2022[67]	Institute Jantung Negana	Malaysia	2019–2021	CABG±valve	242	36.4%	Telemetry	Nonintervention-based (≥30s)
Oraii, 2022[68]	Tehran Heart Center	Iran	2012–2016	CABG	9310	12.9%	Telemetry+ECG	Nonintervention-based (≥30s)
Potdar, 2022[69]	Rabindranath Tagore International Institute of Cardiac Sciences	India	2018	CABG	1108	7.9%	Telemetry+ECG	Intervention-based

AVR indicates aortic valve replacement; CABG, coronary artery bypass grafting; and POAF, postoperative atrial fibrillation.

selection process and the checklist are detailed in Figure S1 and Table S3, respectively. All studies were considered of high or good methodological quality for the purpose of this meta-analysis (Table S4). Eighteen studies (30.5%) were from Asia, 16 (27.1%) from North America, 15 (25.4%) from Europe, 4 (6.8%) from South America, 3 (5.1%) from multiple regions, 2 (3.4%) from Oceania, and 1 (1.7%) from Africa. Thirty-six studies (61%) included patients undergoing isolated CABG, 20 (33.9%) included more than 1 cardiac surgical procedure, 2 (3.4%) included patients undergoing isolated aortic valve replacement, and 1 (1.7%) included patients undergoing total arch repair (Table 1).

A total of 197 774 patients were included in the pooled analysis. The number of patients in each study ranged from 44 to 19 947 with a median sample size of 969 (interquartile range: 364–5362). The cumulative incidence of POAF was 26% (range: 7.3%–53.1%; Figure S2). Twenty-one (35.6%) studies reported POAF incidence based on continuous telemetry until hospital discharge, 30 (50.9%) based on telemetry during ICU stay followed by daily ECG in the regular floor, and 8 (13.6%) based on daily ECG only. Fifteen (25.4%) studies had an intervention-based POAF definition, 36 (61%) a nonintervention-based definition, and 8 (13.6%) did not report POAF definition (Table 1).

The mean age range was 53.7 to 77.4 years in patients with POAF, and 48.0 to 76.5 years in patients without POAF. Female patients ranged from 0.9% to 49.1% in the POAF group and 1.1% to 43.6% in the non-POAF group. The mean left ventricular ejection fraction range was 43.2% to 65.6% in patients with POAF and 44.4% to 64.0% in patients without POAF. The prevalence of hypertension ranged from 35.1% to 95.3% in patients with POAF and 19.7% to 97.0% in patients without POAF. The prevalence of diabetes ranged from 3.2% to 80.0% in patients with POAF, and 3.4% to 60.4% in patients without POAF. The prevalence of chronic obstructive pulmonary disease ranged from 0% to 41.8% in patients with POAF and 0.8% to 36.7% in patients without POAF. Preoperative use of beta blockers ranged from 26.2% to 91.7% in patients with POAF and 24% to 95% in patients without POAF. Demographic data of the patient population in each study are summarized in Table S5.

Meta-Analysis

Primary Outcome

The cumulative incidence of POAF was 26% (range: 7.3%–53.1%). POAF incidence in the group that used continuous telemetry until hospital discharge was 27% (range: 7.3%–53.1%), compared with 27% (range: 7.9%–50%) for the telemetry plus daily ECG group and 19% (range: 7.8%–42.4%) for the group that only used daily ECG. No difference in POAF incidence was found between any of the assessment methods (continuous telemetry versus telemetry plus daily ECG: P=0.89; continuous telemetry versus daily ECG only: P=0.12; telemetry plus daily ECG versus daily ECG only: P=0.09; Table 2; Figure 1A through D and 2; Table S6).

Table 2. Summary of Primary and Secondary Outcomes Based on Assessment Method

Primary outcome				
Outcome	**Comparison group**	**Pooled estimates (range)**	***P* value**	**Tau-squared**
Postoperative atrial fibrillation incidence	Telemetry vs telemetry+ECG	27% (7.3%–53.1%) vs 27% (7.9%–50%)	0.89	0.30 vs 0.25
	Telemetry vs ECG only	27% (7.3%–53.1%) vs 19% (7.8%–42.4%)	0.12	0.30 vs 0.48
	Telemetry+ECG vs ECG only	27% (7.9%–50%) vs 19% (7.8%–42.4%)	0.09	0.26 vs 0.48
Secondary outcomes				
Outcome	**Comparison group**	**Pooled estimates (95% CI)**	***P* value**	
Mortality	Telemetry vs telemetry+ECG	4% (3%–5%) vs 3% (2–4%)	0.29	0.24 vs 0.68
	Telemetry vs ECG only	4% (3%–5%) vs 2% (1–4%)	0.16	0.24 vs 0.76
	Telemetry+ECG vs ECG only	3% (2%–4%) vs 2% (1–4%)	0.47	0.68 vs 0.76
Stroke	Telemetry vs telemetry+ECG	3% (2%–4%) vs 2% (2–3%)	0.30	0.13 vs 0.73
	Telemetry vs ECG only	3% (2%–4%) vs 2% (1–4%)	0.32	0.13 vs 0.17
	Telemetry+ECG vs ECG only	2% (2%–3%) vs 2% (1–4%)	0.88	0.17 vs 0.73
Intensive care unit LOS	Telemetry vs telemetry+ECG	3.7 d (2.1–5.2) vs 3.2 d (2.3–4.1)	0.63	3.56 vs 1.50
	Telemetry vs ECG only	3.7 d (2.1–5.2) vs 3.0 d (1.8–4.3)	0.55	3.56 vs 1.92
	Telemetry+ECG vs ECG only	3.2 d (2.3–4.1) vs 3.0 d (1.8–4.3)	0.82	1.92 vs 1.50
Postoperative LOS	Telemetry vs telemetry+ECG	13.6 d (9.1–18.1) vs 11.0 d (9.4–12.6)	0.29	56.50 vs 12.43
	Telemetry vs ECG only	13.6 d (9.1–18.1) vs 10.1 d (7.7–12.6)	0.18	56.50 vs 8.75
	Telemetry+ECG vs ECG only	11.0 d (9.4–12.6) vs 10.1 d (7.7–12.6)	0.56	12.43 vs 8.75

LOS indicates length of stay.

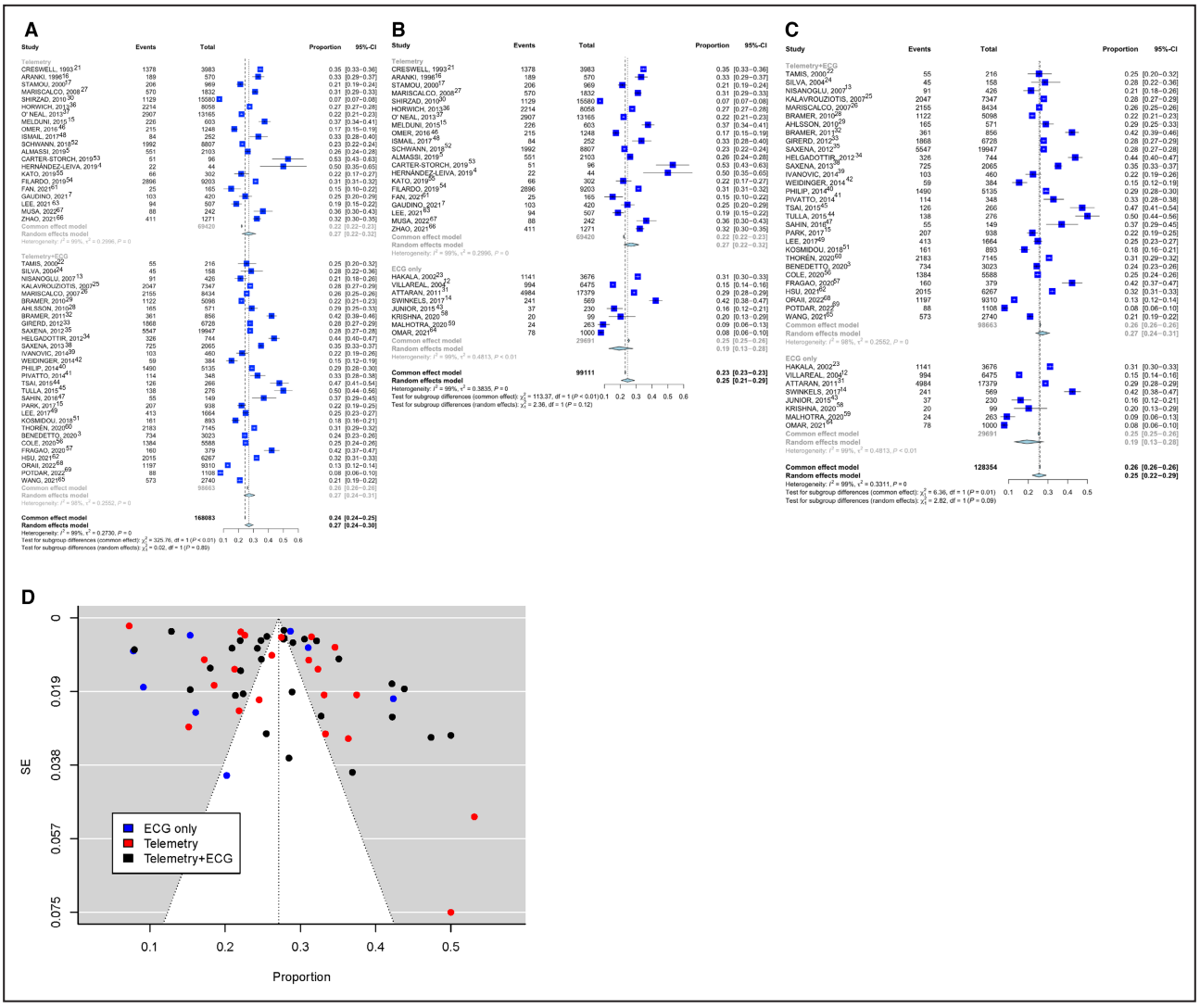

Figure 1. Comparison of postoperative atrial fibrillation incidence by assessment method.
A, Telemetry vs telemetry plus ECG group, *P*=0.89. **B**, Telemetry vs ECG only, *P*=0.12. **C**, Telemetry plus ECG vs ECG only, *P*=0.09. **D**, Grouped funnel plot based on the monitoring approaches with untransformed proportion and standard error (as a measure of precision).

Secondary Outcomes

No differences in in-hospital mortality, stroke, ICU LOS, and postoperative LOS were found between the 3 POAF assessment methods. (Table 2; Figure 2, Tables S7 and S8; Figures S2 through S6).

Secondary Analyses

No difference in POAF incidence was found between intervention- and nonintervention-based POAF definitions (26% [range: 7.9%–47.4%] versus 27% [range: 7.3%–53.1%], respectively; *P*=0.67). No differences in in-hospital mortality, stroke, ICU LOS, and postoperative LOS were found between both definition categories (Table 3; Table S9; Figures S7 through S11).

There was no evidence of publication bias (Egger's intercept test *P*=0.86; Figure S12).

Subgroup Analysis

In CABG studies significant differences in POAF incidence between continuous telemetry and daily ECG (25% [range: 15.2%–33.3%] versus 15% [range: 7.8%–31%], respectively; *P*=0.02), and between telemetry plus daily ECG compared with daily ECG only (26% [range: 7.9–50%] versus 15% [range: 7.8%–31%], respectively; *P*=0.02) were found (Table 4; Figure S13A through C).

Trend in POAF Incidence

There was no significant change in POAF incidence during the study period (*P* for trend=0.54; Figure 3).

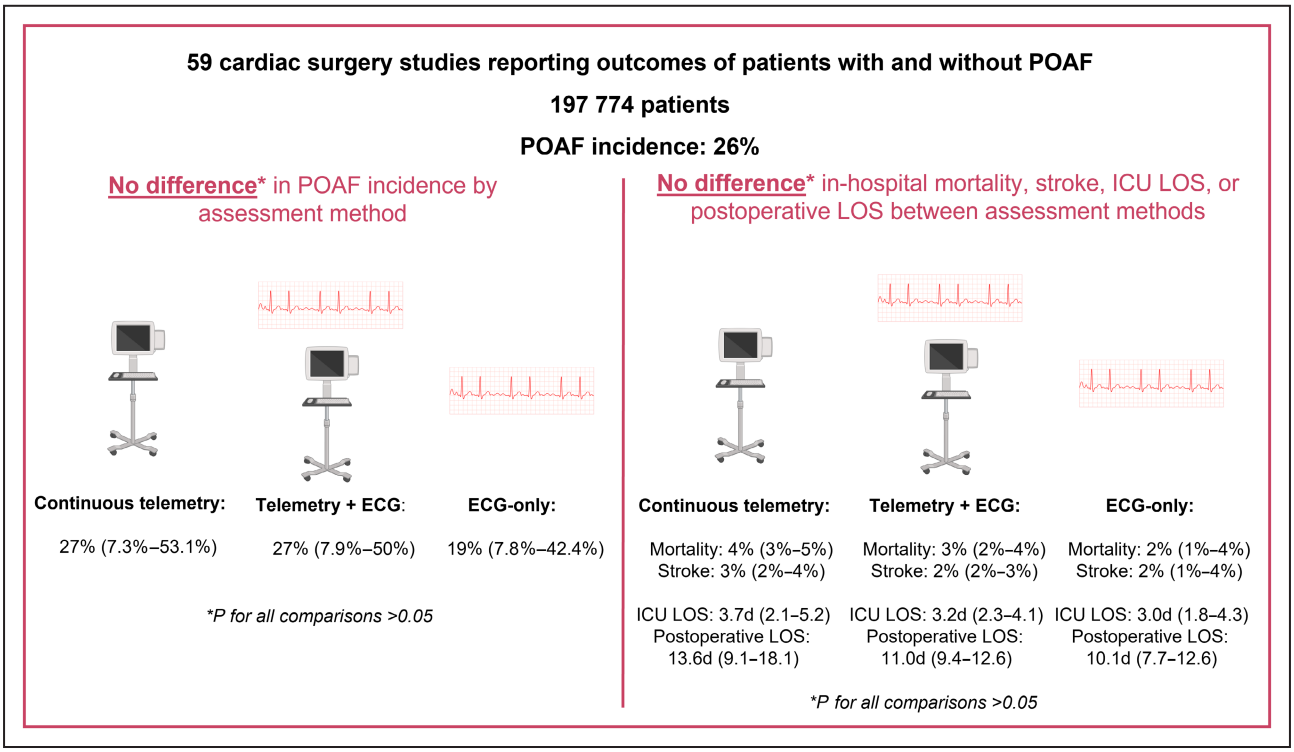

Figure 2. Summary figure of the main results.
ICU indicates intensive care unit; LOS, length of stay; and POAF, postoperative atrial fibrillation.

Meta-Regression

No association between POAF incidence and increasing rigor of the assessment method was found when all cardiac surgeries were considered (beta coefficient 0.17 [95% CI, −0.04 to 0.39, *P*=0.10]); however, an association was found in studies including only patients undergoing isolated CABG where an increase in the rigor of the POAF assessment method was associated with higher POAF detection rates (beta coefficient 0.27 [95% CI, 0.04–0.50], *P*=0.02; Tables S10 and S11).

DISCUSSION

In the present meta-analysis of 59 studies, we found no significant difference in the incidence of POAF after cardiac surgery or its association with adverse outcomes based on the POAF definition or assessment method used; however, in studies including only patients undergoing isolated CABG, continuous telemetry in the ICU and telemetry in the ICU plus daily ECG in the regular ward were associated with higher POAF incidence compared with daily ECG only.

Prior evidence has suggested that continuous telemetry during the complete postoperative hospitalization is associated with higher POAF incidence compared with other assessment methods[70] and this finding was seen also in studies in patients who had noncardiac surgery.[71] Our results did not support this finding when all cardiac surgeries were considered; however, this was the case when considering studies that included only patients undergoing isolated CABG. In this subgroup, the use of telemetry at any point postoperatively (either throughout the postoperative stay or only in the ICU) was associated with higher POAF incidence compared with daily ECG use only. The lack of

Table 3. Summary of Secondary Analyses Based on Postoperative Atrial Fibrillation Definition

Outcome	Intervention-based definition (95% CI, unless noted otherwise)	Nonintervention-based definition (95% CI, unless noted otherwise)	*P* value
Postoperative atrial fibrillation incidence	26% (range 7.9%–47.4%)	27% (range: 7.3%–53.1%)	0.67
Mortality	2% (1%–3%)	2% (1%–2%)	0.69
Stroke	1% (1%–2%)	2% (1%–2%)	0.43
Intensive care unit LOS	2.7 d (1.2–4.2)	2.3 d (1.7–2.8)	0.57
Postoperative LOS	9.7 d (7.1–12.4)	9.5 d (8–10.9)	0.86

LOS indicates length of stay.

Table 4. Summary of the Subgroup Analyses in Studies That Included Only Patients Undergoing Isolated Coronary Artery Bypass Grafting According to Postoperative Atrial Fibrillation Assessment Method

Outcome	Comparison group	Pooled estimates (range)	*P* value
Postoperative atrial fibrillation incidence	Telemetry vs telemetry+ECG	25% (15.2%–33.3%) vs 26% (7.9%–50%)	0.81
	Telemetry vs ECG only	25% (15.2%–33.3%) vs 15% (7.8%–31%)	0.02
	Telemetry+ECG vs ECG only	26% (7.9%–50%) vs 15% (7.8–31%)	0.02

difference in POAF incidence between complete stay telemetry and ICU-only telemetry could be explained by the characteristics of POAF, in that over 70% of POAF episodes occur within 72 hours of surgery[72] and the mean ICU LOS in both groups was approximately 72 hours, suggesting the preponderance of POAF is captured by in-ICU telemetry.

The lack of difference in POAF incidence between intervention- and nonintervention-based POAF definitions could be explained by heterogeneity in the individual study definitions of what is considered treatment of POAF. For example, one study counted POAF episodes only if the arrhythmia required either medical or electrical cardioversion,[33] whereas others limited the description of the definition to *any POAF episode requiring treatment*[48,52] without further elaboration. The range of possible interventions in the last setting includes rate control treatment with beta blockers (received by virtually all patients with POAF in the absence of contraindications), to anticoagulation (with variability in treatment recommendations from different professional societies[11,73,74]) and cardioversion (reserved for patients with hemodynamic instability or resistance/contraindications to medical treatment).

Methodological and Clinical Implications

Our findings have methodological implications for the selection of POAF detection methods in future studies. The main finding is that in patients who had cardiac

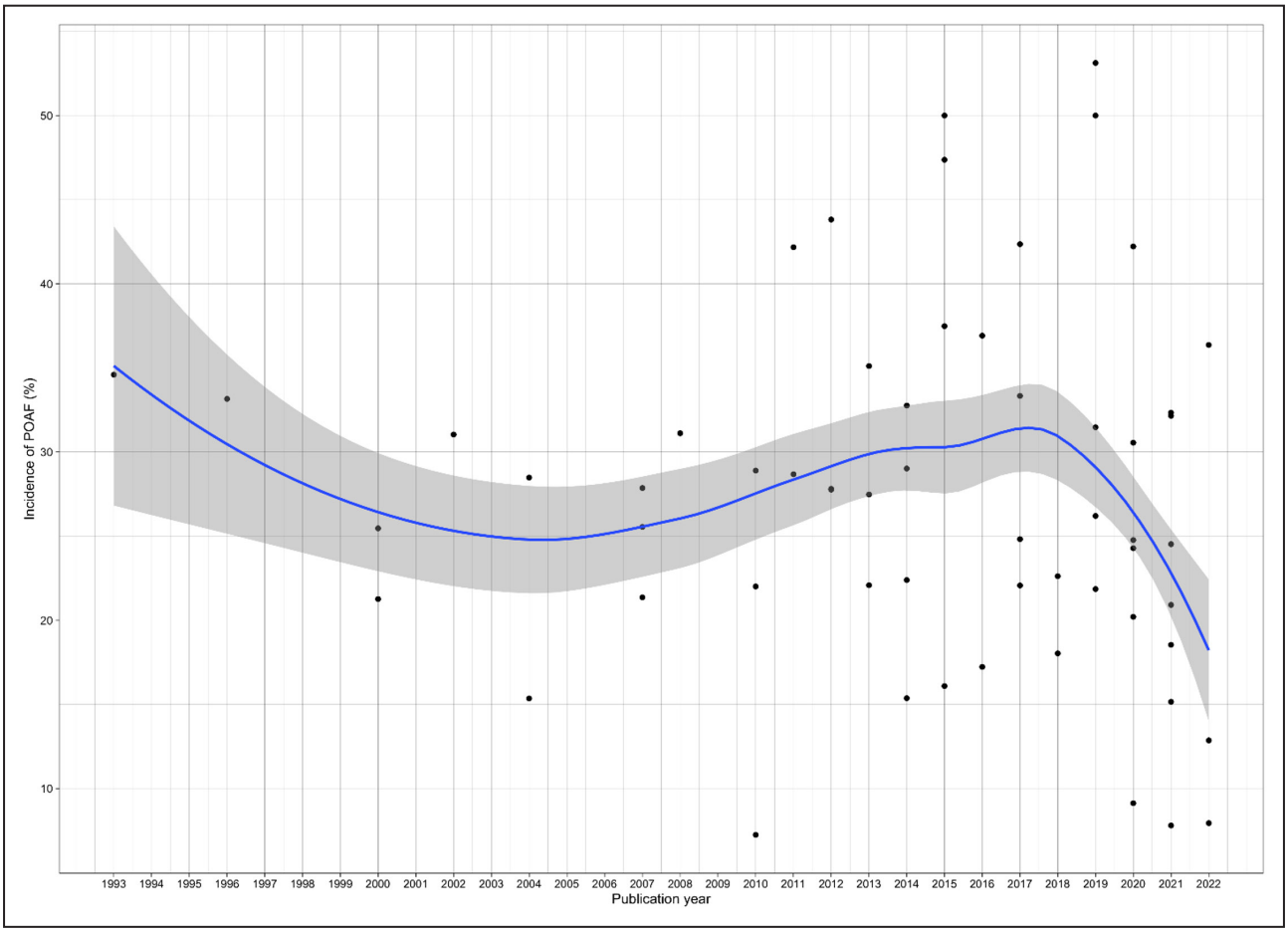

Figure 3. Trends in postoperative atrial fibrillation incidence over the study period.
P for trend=0.54. POAF indicates postoperative atrial fibrillation.

surgery POAF incidence and its association with adverse outcomes are not influenced by the assessment method and definition used. However, in studies that included only patients undergoing isolated CABG, the increasing sensitivity of the POAF assessment method was associated with higher POAF detection rates. While the reason for this difference is unclear, it is possible that the less invasive nature of isolated CABG compared with other cardiac surgeries results in less inflammation and shorter POAF episodes (lasting <24 hours),[1] making POAF less likely to be captured by daily ECG. It is also possible that the shorter duration of ICU stay after CABG may have played a role in the reported difference.

From a clinical standpoint, although POAF rates are not affected by the assessment methods, it must be noted that continuous telemetry monitoring outside of the ICU may allow detection of other clinically relevant arrhythmias and is consistent with recommendations from professional societies.[75]

Limitations

This study must be interpreted considering its limitations. Although our systematic review identified the best available evidence comparing outcomes of patients with and without POAF after cardiac surgery, POAF assessment methods were nonrandomized in all studies, creating the possibility for biases and confounding. Additionally, not all studies reported the secondary outcomes of interest, decreasing the power of some comparisons. Moreover, heterogeneity was high for all the outcomes, and it is also possible that studies that used daily ECG only for POAF assessment come from low-resource centers or are using data from an older era.

CONCLUSIONS

POAF incidence remains high after cardiac surgery, although detection rates exhibit variability among different studies. No differences in POAF incidence, in-hospital mortality, stroke, ICU LOS, and postoperative LOS were found between assessment methods and POAF definitions. POAF incidence was higher in studies that included only patients undergoing isolated CABG that used telemetry for POAF assessment (regardless of whether it was during the whole postoperative stay or only in the ICU) compared with daily ECG only.

ARTICLE INFORMATION

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Supplemental Material

Tables S1–S11
Figures S1–S13

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