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Atrial fibrillation in adults with congenital heart disease following cardiac surgery in a single center: Analysis of incidence and risk factors

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Abstract

Objective: The primary aim of our work is to determine the incidence of atrial fibrillation following cardiac surgery in adults with congenital heart disease. Secondary aims include identifying risk factors predictive of developing early postoperative atrial fibrillation and morbidities associated with early postoperative atrial fibrillation.

Design: Retrospective analysis.

Setting: Single center, quaternary care children's hospital.

Patients: This review included patients at least 18 years of age with known congenital heart disease who underwent cardiac surgery requiring a median sternotomy at our congenital heart center from January 1, 2012 to December 31, 2016.

Interventions: None.

Outcome Measures: The primary outcome was early postoperative atrial fibrillation. Secondary outcomes included preoperative comorbidities, preoperative echocardiographic findings, operative details, and postoperative morbidities, such length of stay, reintubation, stroke, and death.

Results: The incidence of early postoperative atrial fibrillation was 21%. Those who developed early postoperative atrial fibrillation were older (50 years vs 38 years, P =< .001), had a history of atrial fibrillation prior to surgery, had preoperative pulmonary hypertension, and had longer cardiopulmonary bypass times (103 minutes vs 84 minutes, P = .025) when compared to those who did not develop postoperative atrial fibrillation. Multivariate analysis identified age greater than 60, preoperative pulmonary hypertension, mitral valve intervention, and the need for postoperative inotropic support as being independent predictors of postoperative atrial fibrillation. Those who developed postoperative atrial fibrillation remained in the hospital longer (9 days vs 7 days, P =< .001).

Conclusions: Atrial fibrillation is a common complication following cardiac surgery in adults with congenital heart disease. Age, preoperative comorbidities, type of surgical intervention, and the need for perioperative inotropic infusions may predict the risk of atrial fibrillation in this unique patient population.

KEYWORDS

adult congenital heart disease, arrhythmia, atrial fibrillation, cardiac surgery

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1 | BACKGROUND

Atrial fibrillation is one of the most common complications following cardiothoracic surgery in adults. Early postoperative atrial fibrillation occurs in 15%-40% of patients following coronary artery bypass graft surgery (CABG), in 37%-50% after valve surgery, and in as many as 60% undergoing a combination valve and CABG procedure.[1,2] Postoperative atrial fibrillation has been shown to be implicated in many adverse outcomes, including increased risk of stroke, reoperation, multi-organ dysfunction, cardiac arrest, need for permanent pacemaker insertion, and increased all-cause 30-day and 6-month mortality. The development of postoperative atrial fibrillation has been associated with prolonged hospitalization and increased hospital costs.[2-4]

Postoperative atrial fibrillation typically occurs within the first 4 postoperative days, with the highest incidence being on postoperative day 2.[4,5] Several risk factors, including advanced age, history of atrial fibrillation, peripheral vascular disease, pulmonary arterial hypertension,[6] systemic hypertension, left atrial enlargement, left ventricular dysfunction, and obesity have been identified as independent predictors for the development of postoperative atrial fibrillation in adults without congenital heart disease. Several interventions, including beta-blockers, amiodarone, sotalol, magnesium, vitamin C, and atrial pacing have been shown to reduce the incidence of postoperative atrial fibrillation.[5] Guarnieri et al showed that low-dose intravenous amiodarone given over the first 48 hours after cardiac surgery safely reduced the incidence of postoperative atrial fibrillation, with little effect on length of stay and cost.[7]

Little is known about the incidence and risk factors for the development of postoperative atrial fibrillationin adults with congenital heart disease undergoing cardiac surgery. In a study by Chauvaud et al, they reported early postoperative atrial fibrillation in 19.5% of adults undergoing primary surgical repair for Ebstein's anomaly.[8] In the modern era of surgical techniques, more than 90% of children born with congenital heart disease are expected to live until adulthood. While the majority of patients with less complex lesions won't require any interventions as adults, many of those with more complex congenital heart disease will require additional surgical interventions once they reach adulthood. As mentioned in a review by Moe et al, in addition to the standard risk factors for postoperative atrial fibrillation in adults, those with congenital heart disease likely have additional risk factors due to atrial enlargement from uncorrected congenital heart disease, atrial scarring from previous cardiac surgeries, more comorbid conditions, and chronic subendocardial ischemia in those with cyanosis.[9] In the present study, we sought to evaluate the incidence of early postoperative atrial fibrillation in a heterogeneous population of adults with congenital heart disease undergoing cardiothoracic surgery. Second, we hoped to identify risk factors for the development of early postoperative atrial fibrillation and document the postoperative complication rate in those who develop early atrial fibrillation.

2 | METHODS

We performed a single-center, retrospective cohort study of adults with known congenital heart disease who underwent cardiothoracic surgery at the University of Florida Congenital Heart Center from January 1, 2012 to December 31, 2016. Inclusion criteria included age ≥18 years of age and known congenital heart disease. We excluded patients with known interstitial lung disease and those undergoing the following surgical procedures: pacemaker generator exchange only or orthotopic heart transplantation. In our study, the diagnosis of early postoperative atrial fibrillation was established when a patient received intravenous amiodarone due to a hemodynamically significant arrhythmia (defined as hypotension with a systolic blood pressure less than 90 mm Hg, urine output less than 0.5 mL/kg/hour, or a rising lactate) as determined by a cardiac intensivist in the perioperative period. The attending adult congenital cardiologist reviewed the 12-lead electrocardiogram or recorded continuous telemetry within 24 hours of amiodarone initiation to

TABLE 1 Baseline characteristics

Variable	
Mean age (Std. dev.)	41 years (14)
Male	53%
Simple CHD[a]	3%
Moderately complex CHD[a]	86%
Very complex CHD[a]	11%
Preoperative Comorbidities	
Paroxysmal atrial fibrillation	15%
Hypertension	26%
Hyperlipidemia	19%
COPD	8%
Diabetes mellitus	8%
Pulmonary hypertension[b]	10%
Hypothyroidism[c]	14%
Hyperthyroidism[c]	1%
Stroke	6%
Overweight/obese	54%
Peripheral vascular disease	2%
Prior cardiac surgery	64%
Chronic medications	
Beta-blockade	46%
Amiodarone	9%
Calcium channel blocker	10%
Digoxin	9%
Diuretic	30%
ACE inhibitor	30%
Perioperative therapies	
Prophylactic amiodarone infusion	31%

[a]Complexity of congenital heart lesions based on severity classification from the 2008 ACC/AHA Guidelines for the Management of Adults with Congenital Heart Disease.[10]
[b]As defined by mean pulmonary artery pressure >25 mm Hg with elevated trans-pulmonary gradient or indexed pulmonary vascular resistance >3 woods units × m^2.
[c]All patients with historical thyroid disease were euthyroid on laboratory evaluation prior to surgical intervention.

TABLE 2 Study population characteristics

	Atrial fibrillation *n* = 42 (%)	No atrial fibrillation *n* = 159 (%)	*P*
Mean age	50 years	38 years	<.001
Male	22 (52)	84 (53)	1
Simple CHD	2 (5)	4 (3)	.429
Moderately complex CHD	35 (83)	137 (86)	.896
Complex CHD	3 (7)	18 (11)	.456
Preoperative co-morbidities			
Paroxysmal atrial fibrillation	15 (36)	16 (10)	<.001
Hypertension	15 (36)	38 (24)	.167
Hyperlipidemia	12 (29)	26 (16)	.08
Chronic obstructive pulmonary disease	7 (17)	8 (5)	.018
Diabetes mellitus	3 (7)	13 (8)	1
Pulmonary hypertension	10 (24)	11 (7)	.003
Hypothyroidism	10 (24)	18 (11)	.047
Stroke	1 (2)	10 (6)	.465
Overweight/obese	24 (57)	85 (53)	.729
Peripheral vascular disease	1 (2)	2 (1)	.507
Prior cardiac surgery	24 (59)	102 (65)	.466
Chronic medications			
Beta-blockade	23 (55)	69 (43)	.224
Amiodarone	5 (12)	13 (8)	.542
Calcium channel blocker	3 (7)	17 (11)	.772
Digoxin	4 (10)	13 (8)	.759
Diuretic	22 (52)	39 (25)	.001
ACE inhibitor	14 (33)	14 (29)	.575
Preoperative inotropic support	11 (26)	22 (14)	.065
Preoperative Transthoracic Echocardiogram			
LA dilation	13 (34)	30 (22)	.138
At least mild mitral stenosis	4 (10)	5 (3)	.098
At least moderate mitral regurgitation	9 (27)	16 (10)	.068
At least moderate RV dilation	21 (51)	71 (46)	.6
At least mild RV systolic dysfunction	18 (44)	54 (35)	.363
At least moderate LV dilation	9 (21)	26 (17)	.5
At least mild LV systolic dysfunction	8 (19)	31 (20)	1
Operative variables			
STAT score 1*	13 (31)	62 (39)	.374
STAT score 2	16 (38)	68 (43)	.603
STAT score 3	4 (10)	12 (8)	.748
STAT score 4	8 (19)	17 (11)	.186
Pulmonary valve intervention	12 (29)	58 (36)	.464
Tricuspid valve intervention	6 (14)	18 (11)	.591
Aortic valve intervention	7 (17)	24 (15)	.809
Mitral valve intervention	11 (26)	16 (10)	.009
Left-sided maze	6 (14)	4 (3)	.002
Left Atrial appendage ligation	6 (14)	3 (2)	<.001
Median CBP time (minutes)	103	84	.025

(Continues)

TABLE 2 (Continued)

	Atrial fibrillation *n* = 42 (%)	No atrial fibrillation *n* = 159 (%)	*P*
Median AA time (minutes)	68	48	.034
Intraoperative arrhythmia	8 (20)	37 (25)	.677
Postoperative inotropic support	34 (81)	83 (53)	.001

*STS-EACTS congenital heart surgery mortality category (STAT score).

TABLE 3 Postoperative morbidities

Outcomes	Atrial fibrillation	No Atrial fibrillation	*P* value
Median length of stay (days)	9	7	<.001
Reintubation	1 (2)	1 (1)	.377
Stroke	0	2 (1)	1
Readmission	5 (12)	16 (10)	.777
Death (at 6 months)	2 (5)	1 (1)	.111

confirm the diagnosis of atrial fibrillation. This study was approved by the University of Florida Institutional Review Board, with a waiver of informed consent.

Continuous variables were analyzed using the Mann-Whitney U test. Discrete variables were analyzed by Fischer's exact test. Differences were considered significant at $P \leq .05$. For multivariate analysis, binomial logistic regression was performed using discrete variables with a $P < .2$, excluding those with a correlation coefficient >.3.

3 | RESULTS

Two-hundred thirty nine adults with congenital heart disease were admitted to the cardiac intensive care unit from January 1, 2012 to December 31, 2016 following cardiothoracic surgery. Thirty-eight were excluded from analysis due to orthotopic heart transplantation or other noncardiac surgery as the reasons for admission, leaving 201 adults with congenital heart disease for final analysis. The mean age of the cohort was 41 years (SD 14). Twenty-one percent of the adults in our cohort developed atrial fibrillation during their postoperative course (Table 1). The mean age of the patients who developed early postoperative atrial fibrillation was 50 years vs 38 years in patients who did not develop atrial fibrillation. The median cardiopulmonary bypass time (103 minutes vs 84 minutes) and aortic cross-clamp time (68 minutes vs 48 minutes) were longer in patients who subsequently developed early postoperative atrial fibrillation (Table 2). The median length of hospital stay in patients with early postoperative atrial fibrillation was 2 days longer (9 days vs 7 days) than those who did not develop atrial fibrillation. There was no significant difference in readmission rate, stroke rate, or 30-day or 6-month mortality between the two groups (Table 3).

In univariate analysis, the preoperative comorbidities associated with the development of early postoperative atrial fibrillation included advanced age, paroxysmal atrial fibrillation, chronic obstructive pulmonary disease, pulmonary hypertension, hypothyroidism, and the need for preoperative diuresis. The perioperative variables associated with the development of early postoperative atrial fibrillation include mitral valve intervention, cardiopulmonary bypass time longer than 80 minutes, aortic cross-clamp time longer than 60 minutes, and the need for postoperative inotropic support (milrinoneand/or epinephrine) (Table 4).

Multivariate analysis demonstrated age ≥60 years, preoperative pulmonary hypertension, mitral valve intervention, and postoperative inotropic support requirement were independently associated with the development of early postoperative atrial fibrillation (Table 5).

4 | DISCUSSION

To our knowledge, this is the first report evaluating the incidence of and risk factors for the development of early postoperative atrial fibrillation in adults with congenital heart disease. There is ample data on atrial fibrillation following cardiothoracic surgery in adults without congenital heart disease. When compared to the general adult population, our data suggest that adults with congenital heart disease may have a lower incidence of early postoperative atrial fibrillation. This finding does not come as a surprise to our group. We believe the lower incidence of postoperative atrial fibrillation in our cohort of patients is multifactorial. First, the average age of the adults in our cohort who underwent cardiac surgery was almost two decades younger than those in other studies available for comparison. Second, preoperative comorbidities, many of which have been associated with an increased risk of postoperative atrial fibrillation, were far less common in our cohort when compared to those found in other studies.

As anticipated, the risk factors associated with the development of early postoperative atrial fibrillation in our cohort were similar to those found in other adult studies. Advanced age, comorbidities associated with alterations in ventricular compliance and development of arrhythmia substrate, mitral valve intervention, and the need for postoperative inotropic drugs may increase the probability of developing early postoperative atrial fibrillation in adults with congenital heart disease. Somewhat surprisingly, the complexity of congenital heart disease or surgical risk score were not predictive of postoperative atrial fibrillation. In our cohort, a concomitant Maze procedure was rarely performed. Patients who underwent a Maze procedure were more likely to develop early postoperative atrial fibrillation in univariate analysis; however, there was no association in multivariate analysis. Although somewhat surprising, this is a well-described phenomenon occurring in greater than 40% of adult patients undergoing a Maze procedure.[11]

TABLE 4 Univariate analysis of risk factors for atrial fibrillation

Variable	OR (95% CI)	*P*
Age		
60+ (*n* = 24)	4.90 (2.01, 11.9)	<.001
50-59 (*n* = 32)	1.32 (0.547, 3.2)	.635
40-49 (*n* = 42)	1.72 (0.79, 3.75)	.2
30-39 (*n* = 48)	0.7 (0.299, 1.64)	.542
18-29 (*n* = 55)	0.1 (0.0233, 0.430)	<.001
Male	0.982 (0.497, 1.94)	1
Comorbidities		
Atrial fibrillation	4.97 (2.20, 11.2)	<.001
Hypertension	1.77 (0.853, 3.67)	.167
Hyperlipidemia	2.05 (0.928, 4.51)	.08
Chronic obstructive pulmonary disease	3.78 (1.28, 11.1)	.018
Diabetes mellitus	0.864 (0.234, 3.18)	1
Pulmonary hypertension	4.2 (1.65, 10.7)	.003
Hypothyroidism	2.45 (1.03, 5.80)	.047
Hyperthyroidism	0.741 (0.035, 15.7)	1
Stroke	0.363 (0.045, 2.92	.465
Overweight/obese	1.16 (0.585, 2.31)	.729
Peripheral vascular disease	1.91 (0.169, 21.6)	.507
Prior cardiac surgery	0.747 (0.370, 1.51)	.466
Chronic medications		
Beta-blockade	1.58 (0.797, 3.13)	.224
Amiodarone	1.52 (0.509, 4.53)	.542
Calcium channel blocker	0.643 (0.179, 2.31)	.772
Digoxin	1.18 (0.365, 3.83)	.759
Diuretic	3.38 (1.67, 6.85)	.001
ACE inhibitor	1.23 (0.593, 2.54)	.575
Preoperative inotropic support	2.19 (0.964, 4.99)	.065
Preoperative Transthoracic Echocardiogram		
LA dilation	1.85 (0.848, 4.06)	.138
At least mild mitral stenosis	3.18 (0.814, 12.4)	.098
At least moderate mitral regurgitation	2.37 (0.963, 5.83)	.068
At least moderate RV dilation	1.23 (0.616, 2.45)	.6
At least mild RV systolic dysfunction	1.45 (0.720, 2.92)	.363
At least moderate LV dilation	1.34 (0.574, 3.14)	.5
At least mild LV systolic dysfunction	0.926 (0.39, 2.2)	1
Operative variables		
STAT score 1	0.701 (0.34, 1.45)	.374
STAT score 2	0.824 (0.41, 1.65)	.603
STAT score 3	1.29 (0.39, 4.22)	.748
STAT score 4	1.97 (0.78, 4.93)	.186
Pulmonary valve intervention	0.72 (0.34, 1.52)	.464
Tricuspid valve intervention	1.34 (0.50, 3.63)	.591
Aortic valve intervention	1.16 (0.46, 2.91)	.809
Mitral valve intervention	3.28 (1.38, 7.77)	.009

(Continues)

TABLE 4 (Continued)

Variable	OR (95% CI)	*P*
Left-sided maze	6.64 (1.78, 24.8)	.002
Left Atrial appendage ligation	8.91 (2.13, 37.4)	<.001
CPB time (minutes)		
70+	2.04 (0.88, 4.73)	.093
80+	2.41 (1.1, 5.28)	.049
AA time (minutes)		
50+	1.98 (0.96, 4.07)	.164
60+	2.43 (1.19, 4.93)	.03
Intraoperative arrhythmia	0.77 (0.326, 1.82)	.677
Postoperative inotropic support	4.33 (1.81, 10.4)	<.001
Milrinone	4.78 (2.15, 10.7)	<.001
Epinephrine	3.73 (1.84, 7.55)	<.001

TABLE 5 Multivariate analysis of risk factors for atrial fibrillation

Variable	OR (95% CI)	*P*
Co-morbidities		
Age 60+ years	6.2 (2.21, 17.41)	<.001
Pulmonary hypertension	3.39 (1.22, 9.44)	.02
Mitral valve intervention	3.94 (1.49, 10.44)	.006
Postoperative inotropic support	4.7 (1.71, 12.91)	.003

Although the incidence of early postoperative atrial fibrillation appears to be lower in adults with congenital heart disease, the burden is still high. The median duration of hospital admission is two days longer in patients who develop early postoperative atrial fibrillation. In our institution, this is two additional days spent in the cardiac intensive care unit where the costs are high. The incidence of other postoperative adverse events, such as stroke and death, were very rare in our cohort of patients, likely attributable to the relatively young age and lower prevalence of comorbid conditions in comparison to other studies.

Several interventions have been shown to reduce the incidence of postoperative atrial fibrillation in adults following cardiothoracic surgery. Early institution of postoperative beta-blockade and perioperative amiodarone administration have been shown to lower the incidence of early postoperative atrial fibrillation in adults following cardiothoracic surgery.[12] As a center, we have historically opted for treatment rather than prophylaxis of postoperative atrial fibrillation; therefore, it was not possible to review the efficacy of therapies in our cohort. Given the high incidence of postoperative atrial fibrillation in adults with congenital heart disease, more research is needed to determine if these measures can be safely and effectively used in our population to reduce the burden of early postoperative atrial fibrillation.

There are some important limitations to our study. Most importantly, this is a retrospective chart review not immune to the common bias associated with such studies. There was not objective information available for the diagnosis of postoperative arrhythmias in several cases; therefore, some cases of postoperative atrial fibrillation may have been overlooked due to limited documentation. Since we are a quaternary care center with a large geographic referral area, several of the patients in the study did not have long-term follow-up in our system; therefore, the development of late atrial fibrillation after cardiac surgery was not reviewable.

5 | CONCLUSIONS

Postoperative atrial fibrillation is a common complication following cardiac surgery in adults with congenital heart disease. There are several identifiable risk factors that may be used to predict the development of postoperative atrial fibrillation in this unique patient population. As the prevalence of adults with congenital heart disease continues to increase, the development of perioperative care protocols designed to fit their needs becomes increasingly more necessary in order to provide the best care to this fragile population.

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CONFLICT OF INTERESTS

The authors have no conflicts of interest to disclose.

AUTHOR CONTRIBUTIONS

Concept/Design: Brock, Reid, Moguillansky
Data analysis/interpretation: Brock, Coppola,Moguillansky
Drafting article: Brock, Moguillansky
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