

Study of atrial arrhythmias after surgical or device closure of atrial septal defect

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ABSTRACT

Background. Device closure of atrial septal defect (ASD) has emerged as a treatment modality for the past 3 decades and has changed the natural history of ASD compared to that of surgical closure. Early intervention in ASD retards the geometrical and electrical remodelling of the atrium that contributes to the development of atrial tachyarrhythmias. We studied the incidence of atrial arrhythmias in patients undergoing surgical and device closure of ASD.

Methods. We did this retrospective observational study at a tertiary referral centre, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, Kerala. Patients of all age groups undergoing surgical and device closure of ASD between 1 January 2003 and 31 December 2008 were included to compare the incidence and nature of atrial arrhythmias and also analyse the difference in new-onset atrial arrhythmias between the two arms.

Results. Of 277 patients, 144 with surgical closure and 133 with device closure were followed up for 10–15 years. A larger number of men underwent surgical closure (41.7%) compared to device closure (25.6%). The mean (SD) follow-up was 12.6 (3.7) years in the surgical closure group and 10.9 (2.6) years in the device closure arm. There were a larger number of patients with atrial tachyarrhythmias in the surgical closure group (6.3%) compared to the device closure group (0.8%) at baseline ($p=0.02$). A significantly larger number of patients had atrial fibrillation in the surgical closure group (5.6%) compared to the device closure group (0.7%) at baseline ($p=0.003$). Pulmonary hypertension at baseline was present in 38.9% of patients in the surgical closure group and in 23.3% of patients in the device closure

group ($p=0.006$). New-onset atrial arrhythmias occurred in patients ≥ 30 years of age ($p=0.006$) and exclusively in patients with pulmonary hypertension in the surgical group (3.7%) and in the device closure group (6.6%). This was statistically significant in the device closure group ($p=0.05$) but not in the surgical closure group ($p=0.13$). The incidence of new-onset arrhythmias was not statistically significant in both groups.

Conclusions. Atrial arrhythmias were significantly more common in patients who underwent surgical or device closure at ≥ 30 years of age and in patients with pulmonary hypertension. There was no difference in new-onset atrial arrhythmias between the surgical and device closure groups. Our study results suggest that surgical or device closure before 30 years of age and before the development of atrial arrhythmias may be beneficial with respect to the development of atrial arrhythmias.

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INTRODUCTION

Atrial septal defects (ASDs) are common cardiac malformations accounting for 10% of congenital heart defects at birth.¹ The incidence after the advent of echocardiography (ECHO) is estimated to be around 100 per 100 000 live births.² Patients with ASD have a good prognosis with 0.6%–0.7% mortality rate per year in the first two decades of life and thereafter, with every passing decade, it rises from 2.7% to 4.5% to 5.4% to 7.5% per year.¹

Atrial tachyarrhythmias such as atrial fibrillation (AF) and atrial flutter are well documented in adults with ASD and may result in considerable comorbidity and occasional death.^{3,4} The incidence of atrial arrhythmias is related to the age at which patients undergo surgical closure.⁵ Ghosh *et al.* observed a lower incidence of preoperative AF among patients aged 35–50 years than among patients >50 years and a lower incidence of new AF in the former than the latter group.⁶ New-onset atrial flutter or AF was more likely to have developed at follow-up in patients >40 years at the time of surgery than those who were ≤ 40 years, and 60% of patients persisted to have atrial flutter and AF after surgical closure.⁷

Percutaneous device closure of ASD is now an established method of treatment. Since surgical scarring of the atrium is avoided in transcatheter closure of ASD, atrial arrhythmias are expected to have a lower incidence in patients undergoing

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transcatheter ASD closure. However, studies have shown that the incidence of new-onset atrial arrhythmias after device closure increases with age. Vajapey *et al.* noted that new-onset atrial arrhythmias were 8.5%, 17.1% and 32.5%, respectively, for 18–40 years, 41–60 years and >60 years of age at the time of closure.⁸ We aimed to estimate the incidence of atrial arrhythmias in patients undergoing surgical and device closure. Our study also attempted to assess whether a difference exists in new-onset atrial arrhythmias between surgical and device closure patients in the long term.

METHODS

This retrospective observational study was done at Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Thiruvananthapuram, Kerala. Patients belonging to all age groups who underwent surgical and device closure of ASD between 1 January 2003 and 31 December 2008 at SCTIMST were identified by searching the institutional database and included in the study. Patients were excluded if they had an ASD as a part of a complex congenital heart disease, in association with coronary artery disease or other valvular disorders.

The investigating cardiologist informed the consenting patients regarding the proposed study. A consent form, written in either English or Malayalam, was signed by the patient and witness of the patient (as per SCTIMST norms). The case records of patients who underwent surgical and device closure were reviewed, and data regarding the demographic profile, pre- and post-procedural ECHO, electrocardiographic (ECG) and Holter findings were analysed. At the time of assessment, patients were evaluated by history, symptoms, ECG, ECHO and Holter findings.

Atrial tachyarrhythmia was defined as the presence of any AF and atrial flutter. New-onset arrhythmia was identified in patients who experienced an episode of atrial flutter or AF after an intervention (ASD surgical closure or device closure) in a patient known to have been in sinus rhythm before intervention. An episode of AF was termed as paroxysmal AF if it terminates spontaneously or with treatment in <7 days. Persistent AF was defined as all episodes of AF which did not satisfy the criteria for paroxysmal AF.

Statistical analysis

Descriptive statistics for all variable comparisons was done using appropriate univariate hypothesis tests. Categorical variables were expressed as frequencies or percentages and

compared for independent samples using either the Pearson or Fisher exact test. Continuous variables were expressed as either mean (SD) or median (interquartile range) depending on the overall variable distribution. A value of $p \leq 0.05$ was considered statistically significant.

RESULTS

Among 277 patients, 144 patients with surgical closure and 133 patients with device closure were followed up for 10–15 years. There were 94 men and 183 women with a gender ratio of 1:1.94. A higher number of men underwent surgical closure (41.7%) compared to device closure (25.6%). Similarly, women underwent device closure more commonly (74.4%) compared to surgical closure (58.3%). Only ostium secundum (OS)-ASD patients underwent device closure (Table I). The mean (SD) follow-up was 12.6 (3.7) years in the surgical closure group and 10.9 (2.6) years in the device closure arm ($p=0.0001$).

The mean (SD) age at which patients underwent surgical (19.6 [15.85] years) and device closure (19.7 [15.74] years) was not significantly different (Table I). Surgical closure was done in 42 (29.2%) patients and device closure was done in 46 (34.6%) patients at ≤ 18 years of age. Forty patients (27.7%) in the surgical closure group and 39 (29%) in the device closure group were ≥ 30 years of age at the time of closure (Table I).

Paroxysmal AF and persistent AF were found in 9/277 (3.2%) patients at baseline before undergoing ASD closure. Significantly ($p=0.003$) more patients had AF in the surgical closure group (8/144, 5.6%) compared to the device closure group (1/133, 0.7%) at baseline. Four patients each had persistent AF and paroxysmal AF in the surgical closure group at baseline. Significantly ($p=0.02$) more number of atrial tachyarrhythmias were present in the surgical closure group (6.3%) compared to the device closure group (0.75%) at baseline (Table II).

New-onset atrial tachyarrhythmias occurred only in 2 patients in the surgical closure group and 2 patients in the device closure group. The incidence of new-onset arrhythmias was not statistically significant between both groups. Ectopic atrial rhythm occurred more commonly in the surgical closure group (4 patients) than in the device closure group (1 patient), but the difference was not statistically significant. Atrial arrhythmias were found only in patients ≥ 30 years of age (10 v. 0; $p=0.0001$). Pulmonary hypertension was more common ($p=0.0001$) in patients undergoing intervention ≥ 30 years (45 v. 39; $p=0.0001$). New-onset atrial arrhythmias occurred significantly more commonly ($p=0.006$) in patients ≤ 30 years of age (4 v. 0).

TABLE I. Baseline characteristics of patients undergoing atrial septal defect (ASD) surgical and device closure

Parameter	Total $n=277$	Surgical closure $n=144$ (%)	Device closure $n=133$ (%)	p value
Men	94	60 (41.7)	34 (25.6)	0.005
Women	183	84 (58.3)	99 (74.4)	0.005
<i>Age (years) at intervention</i>				
Mean	19.7 (15.79)	19.6 (15.85)	19.7 (15.74)	0.95
≤ 18	88 (31.7)	42 (29.2)	46 (34.6)	0.36
≥ 30	79 (28.5)	40 (27.7)	39 (29)	0.79
<i>Type of ASD</i>				
OS-ASD	246 (88.9)	113 (78.4)	133 (100)	
SVC type SV-ASD	28 (10.1)	28 (19.4)		
IVC type SV-ASD	1 (0.4)	1 (0.7)		
OP-ASD	2 (0.7)	2 (1.3)		

OS ostium secundum SVC superior vena cava SV sinus venosus IVC inferior vena cava OP ostium primum Figures in parentheses are percentages

In the surgical closure group, 29 (72.5%) patients ≥ 30 years of age and 25 (24%) patients < 30 years of age had pulmonary hypertension ($p=0.0001$). Similarly, in the device closure group also, pulmonary hypertension was more common in the older age group (16 [41%]) than in the younger age group (14 [14.9%]; $p=0.003$). The arrhythmias and age distribution in patients with pulmonary hypertension in the entire cohort are given in Table IV.

Among the surgical closure group, AF occurred exclusively in patients with pulmonary hypertension ($p=0.02$) compared to those without pulmonary hypertension. New-onset atrial arrhythmias also occurred only in patients with pulmonary hypertension in the surgical group (2 patients [3.7%]) and in the device closure group (2 patients [6.6%]; Table VII).

The presence of atrial tachyarrhythmia was also not statistically different between both the groups on follow-up. Ectopic atrial rhythm occurred in 4 patients in the surgical closure group and 1 patient in the device closure group, and the difference was not significant ($p=0.37$). The total arrhythmia burden during follow-up was more in the surgical closure than the device closure group (Table VI).

DISCUSSION

In our study, the majority of patients were < 30 years of age when they underwent surgical closure (104, 72.2%) or device closure (94, 70.7%) of the ASD. ASD was more common in women with a woman-to-man ratio of 1.94:1, similar to many published studies.¹⁻⁵ The follow-up duration of patients was significantly more in the surgical closure group than in the device closure group as more device closures were done at our centre between 2006 and 2008, the latter years of patient recruitment.

Atrial tachyarrhythmias occurred only in patients who underwent closure at ≥ 30 years of age. The incidence of atrial tachyarrhythmias was 12.7% in patients ≥ 30 years of age. This is similar to previous studies that showed an increase in the incidence of atrial arrhythmias as the age at the time of closure increased. Vajapey *et al.* showed that the frequencies of atrial arrhythmias pre-procedure for the age groups of 18–40 years, 41–60 years and > 60 years were 1.7%, 4% and 18.8%, respectively.⁸ Oliver *et al.*'s results were similar to our study, where AF was significantly linked to patients undergoing surgery of ASD after 25 years of age.⁹ The results of our study are similar to those of previously published studies, with the incidence of atrial arrhythmias increasing with the age at intervention. We found significantly ($p=0.02$) more atrial tachyarrhythmias in the surgical closure group (6.3%) than in the device closure group (0.75%). This difference in baseline arrhythmias may be due to a selection bias as this is a retrospective study. The most common arrhythmia noted in our study was AF at baseline occurring in 3.2% of patients.

New-onset arrhythmias also occurred only in patients with pulmonary hypertension at the time of intervention and in those undergoing closure at ≥ 30 years of age. This observation is in concordance with another study that showed a significant number of new-onset AF in patients undergoing surgical closure after 25 years of age.³

Vajapey *et al.* showed that after ASD device closure of 215 patients, new-onset atrial arrhythmias occurred in 8.5%, 17.1% and 32.5% in the age groups of 18–40 years, 41–60 years and > 60 years, respectively.⁸ Duong *et al.* showed that new-onset atrial tachyarrhythmia occurred in 6% of patients who underwent ASD device closure after 40 years of age.⁹ The incidence of atrial

TABLE II. Distribution of arrhythmias at baseline

Parameter	Surgical closure (n=144)	Device closure (n=133)	p value
Total atrial fibrillation (AF)	8	1	0.03
Persistent AF	4	1	0.37
Paroxysmal AF	4	0	0.12
Atrial flutter	1	0	1
Total atrial tachyarrhythmias	9	1	0.02

Other arrhythmias: 1 type I Mobitz AV (atrioventricular) block, 1 low right atrial rhythm

TABLE III. Age-wise distribution of arrhythmias and pulmonary hypertension among the two groups

	Surgical closure (n=144)		p value	Device closure (n=133)		p value
	≥ 30 years	< 30 years		≥ 30 years	< 30 years	
Number of patients	40 (27.8)	104 (72.2)		39 (29.3)	94 (70.6)	
Pulmonary hypertension	29 (72.5)	25 (24)	0.0001	16 (41)	14 (14.9)	0.003
Atrial arrhythmias at baseline	9 (2.3)	0	0.0001	1 (0.2)	0	0.29
New-onset arrhythmias	2 (0.5)	0	0.08	2 (0.5)	0	0.08

Figures in parentheses are percentages

TABLE IV. Arrhythmias and age distribution in patients with and without pulmonary hypertension

Parameter	Pulmonary hypertension		p value
	Present n=84 (30.3)	Absent n=193 (69.7)	
Atrial tachyarrhythmias at baseline	9 (10.7)	1 (0.5)	0.0001
New-onset arrhythmias	4 (5.1)	0	0.0063
Age ≥ 30 years	45 (53.5)	34 (17.6)	0.0001

Figures in parentheses are percentages

TABLE V. Arrhythmias in relation to pulmonary hypertension (PAH) in both groups

Parameter	Surgical closure (n=144)		p value	Device closure (n=133)		p value
	No PAH	PAH		No PAH	PAH	
Number	90 (62.5)	54 (37.5)		103 (77.4)	30 (22.5)	
Persistent AF	0	4 (2.8)	0.02	0	1 (3.3)	0.22
Paroxysmal AF	0	4 (2.8)	0.02	0	0	–
Atrial flutter	1 (1.1)	0	1	0	0	–
New-onset arrhythmias	0	2 (3.7)	0.13	0	2 (6.6)	0.05

AF atrial fibrillation Figures in parentheses are percentages

TABLE VI. Total burden of arrhythmias on follow-up in both groups

Arrhythmia	Surgical closure (n=144)	Device closure (n=133)	p value
Persistent atrial fibrillation (AF)	4	1	0.37
Paroxysmal atrial fibrillation (AF)	2	0	0.49
Atrial flutter	3	1	0.62
Total atrial tachyarrhythmias on follow-up	9	2	0.06
Supraventricular arrhythmia	1	2	0.6
Reverted to sinus rhythm	2	1	1.0
Ectopic atrial rhythm	4	1	0.37

arrhythmias in our study is lower probably because patients who underwent device closure at <30 years of age was higher and may be due to the fact that Holter monitoring was not done in all the patients on follow-up. Atrial arrhythmias after device closure occurred in patients who had pulmonary hypertension before device closure. De Bruaene *et al.* also showed that presence of mean pulmonary artery pressures ≥ 25 mmHg had a higher risk of development of new-onset atrial tachyarrhythmias after surgical or device closure of ASD.¹¹

Among patients who underwent surgical closure, new-onset atrial tachyarrhythmia occurred in 2 (1.4%) patients. Both were above 30 years of age at closure and compared to those who underwent closure before 30 years of age, the incidence of new-onset arrhythmias was not statistically significant. Gatzoulis *et al.* showed that new-onset atrial arrhythmias were significantly more common in patients undergoing surgical ASD closure after 40 years.⁷ Berger *et al.* also showed no new-onset atrial arrhythmias in patients undergoing ASD surgical closure at <40 years of age and noted an increasing incidence of atrial flutter and AF with age >40 years.¹² The results of our study were also similar showing no new-onset atrial arrhythmias in patients undergoing ASD surgical closure at or below 30 years of age. The frequency of new-onset arrhythmias is lower in our study compared to published studies.

Only 2 patients in the surgical closure group and 2 patients in the device closure group developed atrial tachyarrhythmias on follow-up. There was no statistically significant difference in the occurrence of arrhythmias among the two groups. The frequency of arrhythmias was low in our study and the number of events was not powered enough to conclusively elicit a difference between ASD surgical closure and device closure in the development of new-onset atrial arrhythmias.

In our study, 7 of 10 patients who had atrial tachyarrhythmias (atrial flutter or AF) before closure, persisted to have AF and atrial flutter. Only 3 patients reverted to sinus rhythm. The patients who had atrial arrhythmias were above 30 years of age at the time of ASD closure. Gatzoulis *et al.* also showed that 60% of patients remained in AF or atrial flutter after ASD closure.⁷

The patients who continued to have tachyarrhythmias were patients who were older than 40 years.¹ Duong *et al.* showed that among patients who had atrial arrhythmias before closure, only 9% reverted to sinus rhythm after device closure.¹⁰ These results were similar to our study results, emphasizing the importance of closure at an earlier age and also before the development of tachyarrhythmias.

Limitations

The retrospective nature of our study curtailed the use of Holter in all recruited patients before surgical or device closure. Holter could not be done on all patients on follow-up and thus we may have missed detection of paroxysmal arrhythmias.

Conclusions

Atrial arrhythmias were significantly common in patients who underwent surgical or device closure at ≥ 30 years of age and in patients with pulmonary hypertension. There was no difference in new-onset atrial arrhythmias between patients who had surgical closure and device closure. A majority of patients who developed atrial arrhythmias before surgical or device closure of ASD continued to have arrhythmias after surgical/device closure and did not revert to sinus rhythm. Our study results suggest that surgical/device closure should be done before 30 years of age and also before the development of atrial arrhythmias.

Conflicts of interest. None declared

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