Short-Term Cardiac Rhythm and Conduction Abnormalities Among Children Following Atrial Septal Defect Closure

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Abstract

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Atrial septal defects (ASD) are one of the most common congenital heart defects in human populations—up to 1% of newborns. In cases where the ASD is large, patients usually have two options to have the defect closed: open heart surgery or catheter intervention. One of the complications that can occur after such interventions is incident cardiac arrhythmias or conduction disorders, but there are almost no publications that compares the occurrence of these complications between the two closure techniques.

This single-institution study employed a retrospective cohort design, using a hospital administrative database at Seattle Children's Hospital. I compared the incidence of cardiac arrhythmias or conduction disorders among pediatric patients who underwent "simple" ASD closure either surgically (n=191) or via a catheter-based (n=708) approach during the years 2009-2025. Patients were evaluated in the first 24 hours after the index procedure, to ensure the length of the observation period between the two groups was consistent and uniform.

During the observation period – a time during which all patients remain in the hospital for evaluation – the cumulative incidence of major arrhythmias and conduction disorders (as a whole) was relatively infrequent but higher in the surgical group, with an aggregate risk difference (RD) of approximately 3 per 100. Neither the incidence of cardiac arrest nor cardioversion was different between the two treatment groups. There were no differences in the proportion of children in the catheter and surgical groups who had a clinical condition that might bear on the occurrence of an arrhythmia or conduction disorder. The higher risk difference in the surgical group suggests that arrhythmias and conduction disorders are more likely to occur with surgical patients, at least within the immediate post-procedure period. Studies with longer term follow-up would be desirable.

INTRODUCTION

Atrial septal defects (ASD) are one of the most common congenital heart defects in human populations—up to 1% of newborns [1]. A small ASD can close spontaneously. However, a large defect gives rise to heart enlargement, arrhythmias, and high pressures in the lungs, and a medical intervention is required.

Patients usually have two options to have the defect closed: open heart surgery or catheter intervention. Earlier studies [2, 3] have demonstrated a high degree of efficacy and safety of closure with either approach, although persistent or intraprocedural arrythmias have been present in 6 percent of cases. And there are knowledge gaps, especially related to the use of devices that have not previously been evaluated. The past decade has seen improvements in surgical bypass techniques and a larger range of ASD closure devices.

In this study, I compare the short-term incidence of cardiac arrhythmias in patients diagnosed with simple atrial septal defects, who have undergone either surgical or catheter-based closure at Seattle Children's Hospital.

METHODS

This study employed a retrospective cohort design, using the hospital/administrative database of Seattle Children's Hospital. Any child diagnosed with an ASD who underwent either surgical or catheter closure during 2009-2025 was identified for potential inclusion in the study. Patients were excluded from the cohort if they had complex congenital heart disease, defined as: 1) the need for additional open heart or catheter-based interventions; or 2) the presence of any other

hemodynamically significant lesion. For example, this would include valvular stenosis or regurgitation, or great artery stenosis such as aortic coarctation. Other examples of excluded conditions were cardiomyopathy, great arterial diseases such as transposition or coarctation, and systemic venous or pulmonary venous anomalies. Also, patients who had undergone catheter or medical interventions for arrhythmias prior to the index surgery were not included in the analysis.

Setting

I utilized a network called TriNetX LIVE (Cambridge, Massachusetts; https://trinetx.com). TriNetX is a "…federated network of real-world data in partnership with healthcare providers."[4]. Clinical data from Seattle Children's are amalgamated within TriNetX framework, and the dataset is queried through a web-based user interface called the Clinical Data Repository (CDR). TriNetX Network provided access to de-identified electronic medical records (diagnoses, procedures, medications, laboratory values, genomic information) from approximately 998,000 patients from Seattle Children's. Demographic and baseline data were collected, including height, weight, age at time of procedure. Information on comorbidity diagnoses, such as pulmonary hypertension, history of premature birth, or systemic hypertension, also was collected.

Definition of arrhythmias and conduction disorders

Within the TriNetX network, diagnoses are organized based on the tenth version of the International Classification of Disease (ICD-10), initially released by the World Health Organization in 1992. The outline below lists the outcomes that were assessed.

1. "Major arrhythmia":
    a. Supraventricular tachycardia
    b. Ventricular tachycardia
    c. Atrial fibrillation and flutter
    d. Ventricular fibrillation and flutter
    e. Sick sinus syndrome
2. Conduction disorders
    a. Atrioventricular and left bundle-branch block
    b. Atrioventricular block, first degree
    c. Atrioventricular block, second degree
    d. Atrioventricular block, complete
    e. Other Conduction Disorders
    f. Other and unspecified right bundle-branch block
    g. Other specified heart block
    h. Conduction disorder, unspecified
3. Surrogate conditions for major arrhythmias
    a. Cardiac Arrest
    b. Pacemaker Placement
    c. Cardioversion – Electrical or Drug

An original intent of the study design was to collect minor rhythm diagnoses as well. However, the coding of minor arrhythmias in the database was not sufficiently granular to be able to generate a clinically meaningful analysis.

Data Analysis

The study sought to document the proportion of children with a treated ASD who developed an arrhythmia within the first 24 hours of treatment, both for major arrhythmias and conduction disorders.

Demographic and clinical characteristics were considered, in the event that there were differing proportions of such characteristics between the two treatment groups. Clinical characteristics included the presence of systemic or pulmonary hypertension and a history of prematurity (as a surrogate for potential pulmonary hypertension). These conditions can have a hemodynamic impact on the heart, which in turn may influence the likelihood of arrhythmias or conduction disorders.

RESULTS

From the years 2009-2025 a total of 899 patients were identified -- 708 patients underwent catheter-based closure, and 191 patients underwent surgical closure. There were no deaths in the first 24 hours after the procedure. Mean age at the time of surgery was about seven years among patients in both treatment groups. Similarly, surgical and catheter patients differed little by gender, race, height and weight. While the prevalence of pulmonary heart disease, pulmonary hypertension and systemic hypertension differed little between patients in the surgical and catheter groups, prematurity was more common in surgical patients (6.6 versus 1.7 percent).

In the first 24 hours after the index procedure, outcomes of interest – arrhythmias, conduction disorders and surrogate diagnoses – are listed in Tables 2-4. Listed diagnoses are not mutually exclusive since diagnostic codes can be assigned throughout the 24-hour observation period; an individual patient may have more than one diagnosis. The incidence of major arrhythmias was higher in the patients who underwent surgical closure: 5.8 per hundred (n=11), versus 1.7 per hundred (n=12) in those who underwent catheter closure (risk difference of 4.0 per 100, 95% CI 0.6, 7.5 per 100). This increase was almost entirely due to the increased risk of ventricular tachycardia (n=4), risk difference of 1.7 per 100, and ventricular fibrillation/flutter (n=4), risk difference of 2.1 per 100 in the surgical group. The incidence of the other classes of major arrhythmias differed little between the two treatment groups.

For the aggregate of all conduction abnormalities, the incidence was higher in the surgical group: the difference was 3.0 per hundred, 95% CI -1.0, 6.9 per 100 (Table 3). The difference was spread relatively evenly across the specific types of conduction abnormalities, including the most clinically critical diagnosis – complete atrioventricular block (also known as complete heart block) – for which three cases occurred among catheter patients (0.4%) and none among surgical patients.

Cardiac arrest occurred in two of the patients treated by means of catheterization (0.3%) and in none of the surgically treated patients. Cardioversion was required in 10 catheter-treated children (1.4%) and 2 surgical patients (2.1%).

DISCUSSION

In this retrospective cohort study, I evaluated short term arrhythmia outcomes in a single center for patients undergoing simple ASD closure either via cardiac catheterization or cardiac surgery. Incident arrhythmias in the first 24 hours were relatively uncommon. Cumulative risks of major arrhythmias were higher in the surgical group by about 3-4 per hundred procedures. There was also a similarly higher incidence of conduction disorders, as a whole, in the surgical group. However, when evaluating individual conduction disorders, there was a suggestion of a higher incidence of complete heart (atrioventricular) block in the catheter group – four cases (0.3%) versus none in the surgical group (95% CI -1.0, 6.9 per 100). If the difference were real, it would be important to note, since there would have been a possibility of the need for pacemaker placement at a later time – outside the 24-hour window – if the block were to persist. However, the relatively small size of the surgical group argues for a cautious interpretation of the observed difference.

I could identify no prior study that has directly examined differences between therapeutic approaches to ASD closure with regard to the occurrence of an arrhythmia or conduction disorder. Tanghöj et al. evaluated a broad range of adverse events, including arrhythmias, in a cohort study of approximately 400 Swedish children with ASDs who underwent either surgical or catheter closure [5, 6], but did not present data for the occurrence by type of treatment modality.

In the present study, the focus on arrhythmias during the first 24 hours ensures a similar time period of observation for both surgical and catheterization groups: At Seattle Children's Hospital, all ASD closure patients are invariably observed at least overnight in the hospital. During this period, all patients remain on cardiac telemetry, during which there is continuous monitoring for arrhythmia. However, patients who undergo surgery are typically observed in the cardiac

intensive care unit (ICU) in the first 24 hours, while catheter patients are typically located on general inpatient floors. While all patients are under cardiac telemetry in all parts of the hospital, in the ICU there may be a greater degree of scrutiny and attention to arrhythmia findings.

There are several additional limitations to this study. A history of prematurity was more frequent in the catheter than the surgical group (6.6% versus 1.7%). This diagnosis was intended to be evaluated as a potential confounder given that up to 25% of patients with premature birth can develop pulmonary hypertension, which could in turn affect cardiac rhythms. However, due to a limitation in the TriNetX network – which cited privacy reasons – I was not permitted to examine the difference between patients with and without prematurity for the incidence of major arrhythmias. Also, I could not ascertain whether any of the arrhythmias were transient or persistent. Another important limitation is that, given the concern of underascertainment of arrhythmias following hospital discharge, I chose not to evaluate the occurrence of arrhythmias after the first 24 hours. Finally, arrhythmias and conduction disorders were not coded to the level of specificity that would be clinically desirable, and there is a possibility for misclassification. For example, the ICD-10 code I49.8 is officially listed as “Other specified cardiac arrhythmias” rather than “Ectopic atrial tachycardia” or “sinus arrhythmia”; the former diagnosis is a potentially serious and even life-threatening disease, while the latter is a benign finding.

There may be a plausible explanation for the higher incidence of major arrhythmias in surgical patients. To surgically close an ASD, the heartbeat must be physically stopped using an infusion. To temporarily replace heart circulation, the patient is placed on a cardiopulmonary bypass machine. During the process of restarting the heart after closing the ASD, some patients can develop an abnormal ventricular rhythm, which can be an expected development, and is typically benign and transient.

In conclusion, this study compares the incidence of major arrhythmias and conduction disorders in the first 24 hours following surgical or catheter ASD closure. Risk of major rhythm and conduction disorders, in aggregate, were higher in the surgical group but to a relatively small degree. Studies of this question with longer term follow-up would be desirable.

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Table 1. Demographic and clinical characteristics of patients receiving closure of an atrial septal defect (ASD) during 2009-2025, by type of closure. Excluding the row with age values, remaining values in each column represent percentages (%).

	Cardiac Catheterization n = 708		**Cardiac Surgery n = 191**	
	Counts (n)	Proportion (%)	Counts (n)	Proportion (%)
Age (years (mean ± SD))	708	7.0 ± 5.4	191	6.7 ± 5.3
Sex				
Male	265	37.4	81	42.4
Female	443	62.6	110	57.6
Race				
White	361	51.0	100	52.4
Other Race	165	23.3	46	24.1
American Indian or Alaska Native	55	7.8	17	2.6
Asian	44	6.2	18	9.4
Black or African American	27	3.8	4	2.1
Native Hawaiian or Other Pacific Islander	4	0.6	1	0.5

Unknown Race	52	7.8	17	8.9
Ethnicity				
Not Hispanic or Latino	512	72.3	138	72.3
Hispanic or Latino	157	22.2	38	19.9
Unknown Ethnicity	39	5.5	15	7.9
Additional Diagnoses				
Pulmonary heart disease and diseases of pulmonary circulation	118	16.7	30	16.0
Primary pulmonary hypertension	12	1.7	1	0.5
Prematurity (Disorders of newborn related to short gestation and low birth weight)	52	6.6	7	1.7
Hypertensive diseases	36	5.1	9	4.7

Table 2. Major arrhythmia outcomes within the first 24 hours after the index procedure, by type of procedure. Risk Difference is calculated as the risk in the surgical group minus the risk of the catheter group.

Diagnosis	Catheterization	Risk (%)	Surgery	Risk (%)	Risk Difference (95% CI)
ALL MAJOR ARRHYTHMIAS	12	1.7	11	5.8	4.0 (0.6, 7.5)
Sick Sinus Syndrome	1	0.1	1	0.5	0.4 (-0.1, 0.9)
Atrial Fibrillation and Flutter	4	0.6	1	0.5	-0.04 (-1.1, 1.2)
Supraventricular tachycardia	5	0.7	1	0.5	-0.2 (-1.0, 1.4)
Ventricular tachycardia	3	0.4	4	2.1	1.7 (-0.4, 3.8)
Ventricular Fibrillation and Flutter	0	0	4	2.1	2.1 (-0.1, 4.1)

Table 3. Conduction disorders within the first 24 hours after the index procedure, by type of procedure. Risk Difference is calculated as the risk in the surgical group minus the risk of the catheter group.

Diagnosis	Catheterization	Risk (%)	Surgery	Risk (%)	Risk Difference (95 % CI)
ALL CONDUCTION DISORDERS	31	4.4	14	7.3	3.0 (-1.0, 6.9)
Atrioventricular block, complete	3	0.4	0	0	-0.4 (-0.9, 0.1)
Atrioventricular and left bundle-branch block	11	1.6	6	3.1	1.6 (-1.0, 4.2)
Atrioventricular block, first degree	5	0.7	4	2.1	1.4 (-0.7, 3.5)
Atrioventricular block, second degree	1	0.1	1	0.5	0.4 (-1.4, 0.7)
Other Conduction Disorders	20	2.8	8	4.2	1.4 (-4.5, 1.7)
Other and unspecified right bundle-branch block	14	2.0	6	3.1	1.1 (-3.8, 1.5)
Other specified heart block	1	0.1	0	0	-0.1 (-0.1, 0.4)
Conduction disorder, unspecified	1	0.1	1	0.5	0.4 (-1.4,0.7)

Table 4. Surrogate conditions for major arrhythmias within the first 24 hours after the index procedure. Risk Difference is calculated as the risk in the surgical group minus the risk of the catheter group.

Diagnosis	Catheterization	Risk (%)	Surgery	Risk (%)	Risk Difference (95 CI)
ALL SURROGATES	14	2.0	5	2.6	0.6 (-1.8, 3.1)
Cardiac Arrest	2	0.3	0	0	-0.3 (-0.1, 0.7)
Pacemaker Placement	2	0.3	1	0.5	0.2 (-0.9, 1.3)
Cardioversion – Electrical and/or Drug	10	1.4	4	2.1	0.7 (-1.5, 2.9)