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Evaluation of Arrhythmia Prevalence, Management, and Risk Factors in Patients with Transcatheter and Surgically Closed Secundum Atrial Septal Defects

Transkateter ve Cerrahi Olarak Kapatılan Sekundum Tip Atriyal Septal Defektli Olguların Aritmi Sıklık, Yönetim ve Risk Faktörlerinin Değerlendirilmesi

ORIGINAL ARTICLE
KLİNİK ÇALIŞMA

ABSTRACT

Objective: Atrial septal defect (ASD) accounts for 6-10% of all congenital heart disorders. Secundum ASD closure can be performed surgically or percutaneously. We aimed to identify the various arrhythmias that occur before, during, and after the procedure and evaluate their management.

Methods: The study included a total of 427 patients aged 0-18 years who underwent transcatheter or surgical closure of isolated secundum ASD between January 2008 and January 2020. Postoperative electrocardiogram (ECG) traces, intraoperative arrhythmias, and treatments were recorded for both groups. Echocardiography and ECG were evaluated at postoperative 1 week, 1, 3, and 6 months, and annually thereafter.

Results: After transcatheter closure, follow-up basal ECG showed incomplete right bundle branch block pattern in 21 patients and sinus rhythm in 229 patients. After surgical closure, incomplete right bundle branch block pattern was detected in 23 patients, complete right bundle branch block in 3 patients, and complete AV-block (Atrioventricular Block) pattern in 1 patient. The other 150 patients showed sinus rhythm. At least one postoperative follow-up Holter ECG record could be obtained for 104 patients in the transcatheter group and 96 patients in the surgical group. Of 104 patients who underwent transcatheter closure, 97 (93.3%) had normal Holter ECG findings and 7 (6.7%) had arrhythmia. Of the 96 patients who underwent surgical closure, 85 (88.5%) had normal Holter ECG traces and 11 (11.5%) had arrhythmia. There was no statistically significant difference in the frequency of arrhythmia (P = 0.164).

Conclusion: The higher frequency of arrhythmia in adult studies compared to the pediatric age group once again demonstrates the importance of early diagnosis and treatment of ASD in childhood. The similar incidence of arrhythmia in both groups supports the safety and effectiveness of both closure methods in eligible patients.

Keywords: Arrhythmia, atrial septal defects, surgery, transcatheter

ÖZET

Amaç: Atriyal septal defekt (ASD), tüm doğuştan kalp hastalıklarının %6-10'unu oluşturur. Sekundum ASD kapatma; cerrahi veya perkütan olarak yapılabilir. İşlem öncesi, sırası ve sonrasında ortaya çıkan çeşitli aritmileri belirleyip, yönetimini değerlendirmeyi amaçladık.

Yöntemler: Çalışmaya Ocak 2008 ile Ocak 2020 arasında izole sekundum ASD'nin transkateter veya izole cerrahi olarak kapatılması uygulanan 0-18 yaş arası toplam 427 hasta dahil edildi. Her iki grup için postoperatif EKG kayıtları, intraoperatif aritmiler ve tedavileri kaydedildi. Ekokardiyografi ve EKG, postoperatif 1. hafta, 1, 3 ve 6. aylarda ve sonrasında yıllık olarak değerlendirildi.

Bulgular: Transkateter kapama sonrası, izlemdeki bazal EKG kayıtlarında; 21 hastada inkomplet sağ dal bloğu paterni saptandı. 229 hastada EKG sinüs ritminde saptandı. Cerrahi kapama

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sonrası izlemdeki bazal EKG kayıtlarında; 23 hastada inkomplet sağ dal bloğu paterni, 3 hastada komplet sağ dal bloğu, 1 hastada komplet AV tam blok paterni saptandı. 150 hastanın EKG sinüs ritminde izlendi. Transkateter grubundaki 104 hasta ve cerrahi grubundaki 96 hasta için en az bir postoperatif takip Holter EKG kaydı alınabildi. Transkateter kapatılan 104 hastanın 97'sinde (%93,3) normal Holter EKG bulguları, 7'sinde (%6,7) aritmi vardı. Cerrahi olarak kapatılan 96 hastanın 85'ünde (%88,5) normal Holter EKG bulguları, 11'sinde (%11.5) aritmi vardı. Aritmi sıklığında istatistiksel olarak anlamlı bir fark yoktu (P = 0,164).

Sonuç: Erişkinlerde yapılan çalışmalarda aritmi sıklığının pediatrik yaş grubuna göre daha yüksek olması, çocukluk çağında ASD'nin erken tanı ve tedavisinin önemini bir kez daha ortaya koymaktadır. Her iki grupta benzer aritmi insidansı saptanması, uygun hastalarda her iki kapatma yönteminin de güvenliğini ve etkinliğini desteklemektedir.

Anahtar Kelimeler: Aritmi, atriyal septal defektler, cerrahi, transkateter

Atrial septal defect (ASD) accounts for 6%–10% of all congenital heart disorders. It is twice as common in females as in males. Secundum-type ASDs are the most frequent and are relatively easier to treat than other types.[1] Secundum ASD closure can be performed surgically or percutaneously. Although there are some criteria for the method and timing of secundum ASD closure, the decision is made for each patient individually based on the evaluation of their clinical and hemodynamic status. It is generally appropriate to close secundum ASDs over 7–8 mm after the age of 4 years. However, closure is also recommended if the catheterization-derived pulmonary-to-systemic flow (Qp/Qs) ratio is higher than 1.5. If this ratio is low, the defect is not hemodynamically significant, and closure is not indicated. Very large defects can be closed even in infancy. In recent years, the use of ASD closure devices has further lowered the age at closure.[2] Presently, closure using a transcatheter device is the first-line treatment option. Candidates for surgical closure are patients with failed closure using this method and those with large defects or deficient rims.

Increased atrial distension due to congenital electrophysiological changes in the sinus node or conduction system and increased volume load have been implicated in the development of sinus node dysfunction and atrial tachycardia. Sinus node, atrial, or atrioventricular (AV) node tissue damage after surgery causes arrhythmias. Approximately 40% of cardiac arrhythmias occur before or after surgical ASD closure.[3] Atrial reentry tachycardia, atrial fibrillation, and atrial flutter have been reported in surgical patients even at an early age.[4] Several studies have also documented episodes of arrhythmia in patients undergoing transcatheter closure.[5-7]

In this study, we aimed to evaluate and compare the frequency of arrhythmia on Holter electrocardiography (ECG) in patients with transcatheter and surgically closed secundum ASD and to identify factors associated with arrhythmia in these cases. Additionally, we aimed to identify the various arrhythmias that occur before, during, and after the procedure and evaluate their management.

ABBREVIATIONS

ASD	Atrial septal defect
AV	Atrioventricular
ECG	Electrocardiography
PAP	Pulmonary Artery Pressure
PVR/SVR	Pulmonary vascular resistance/systemic vascular resistance ratio index
PVRI/SVRI	Pulmonary vascular resistance/systemic vascular resistance ratio
Qp/Qs	Pulmonary-to-systemic flow
SVT	Supraventricular tachycardia

Methods

Patient Selection

The study included 427 patients aged 0–18 years who underwent transcatheter or surgical closure of isolated secundum ASD between January 2008 and January 2020 in the pediatric cardiology and pediatric cardiac surgery units of Health Sciences University Dr. Behçet Uz Pediatrics Department. Patients who had isolated ASD secundum associated with other congenital cardiac anomalies and those with incomplete data were excluded. Ethics committee approval was obtained from the scientific research ethics committee of the Dr. Behçet Uz Pediatrics Hospital. The parents or caregivers of all participants were informed in writing and provided informed consent before inclusion in the study.

Echocardiography

Patients were evaluated via echocardiography before, during, and after the procedure. Transthoracic and transesophageal echocardiography procedures were performed using the Vivid 3 echocardiography device (GE, Vingmed Ultrasound, Norway). ASD closure was done in patients with signs of right ventricular loading and dilation and those with pronounced left–right shunt and Qp/Qs ratio >1.5. Patients with ASDs other than secundum ASD, those with concomitant cardiac pathology requiring surgery, and those with Eisenmenger syndrome were evaluated via echocardiography. Transcatheter closure was planned for patients with

rims larger than 5 mm, other than the aortic rims. For patients with floppy rims and multiple defects and patients with large defects, those deemed eligible after detailed transesophageal echocardiographic examination underwent transcatheter closure; otherwise, surgical closure was performed.

Hemodynamic Data

The patients' symptoms before the percutaneous or surgical procedure, age, sex, weight, height, physical examination findings, ECG records, hemogram, biochemistry, coagulation values, defect diameter and rim dimensions, size of the right heart structures, tricuspid valve insufficiency (on echocardiography), and the type and size of closure device used were recorded. Percutaneous closures were performed under anesthesia in the angiography room. Pulmonary artery pressures, right ventricular pressures, Qp/Qs ratio, pulmonary vascular resistance/systemic vascular resistance ratio (PVR/SVR), and index (PVRI/SVRI) measurements were recorded.

Transcatheter ASD Closure Procedure

All patients were sedated. ASD diameter and the aortic and vena cava rims were measured via transesophageal or transthoracic echocardiography. In patients eligible for transcatheter closure, an introducer sheath was placed in the right femoral vein under local anesthesia. To access the right atrium–superior vena cava, right atrium–right ventricle, and pulmonary artery, a multipurpose catheter was advanced to the inferior vena cava via the femoral venous route. Pulmonary artery pressure, right ventricular pressure, Qp/Qs ratio, PVR/SVR, and PVRI/SVRI measurements were recorded. The closure was performed in patients with Qp/Qs ratio >1.5. A rigid guidewire multipurpose catheter was navigated through the right femoral vein to the left atrium. The carrier system was advanced over the guidewire and the left atrial disc of the closure device was opened. The right atrial disc was then opened at the appropriate angles under transesophageal or transthoracic echocardiographic guidance to position the device in the interatrial septum. After ensuring correct placement, the device was disengaged from the carrier system. During the procedure, 50 units/kg of heparin was administered intravenously. The patients used oral 3–5 mg/kg/day aspirin for 6 months after the procedure.

Surgical Procedure

Under general anesthesia, a median sternotomy was performed, followed by total or partial thymectomy. A pericardial patch was prepared with 0.6% glutaraldehyde. After an intravenous bolus of 3 mg/kg heparin, aortic–bicaval cannulation was performed. Under 32°C–34°C hypothermia, an aortic cross-clamp was placed, and cardiac arrest was induced with cold-blood cardioplegia administered every 20 min. Right atriotomy was performed to visualize the ASD. The ASD was closed with the patch via continuous suturing with 5.0 polypropylene suture (Prolene). Warming was initiated while closing the right atriotomy. The aortic cross-clamp was removed after de-airing. If spontaneous heart activity did not resume, defibrillation was performed. After decannulation, drains were placed, hemostasis was achieved, and the tissue layers were closed anatomically.

Holter Monitoring and Arrhythmia Identification

Postoperative ECG traces, intraoperative arrhythmias, and treatments were recorded for both groups. Echocardiography and ECG were evaluated at postoperative 1 week, 1, 3, and 6 months, and annually thereafter. Holter ECG was performed at 1 and 2 years. Holter ECG recordings were obtained over 24 h using a six-channel Holter ECG device (DMS 300-7 HolterReader; DMS, Stateline, NV, USA). The Holter ECG traces were evaluated using the CardioScan 12.0 program (DM Software Inc). Pediatric cardiologists experienced in reading Holter data evaluated the patients' traces after removing artifacts. Arrhythmias that developed during postoperative follow-up and treatment methods were noted. Patients whose Holter ECG records were not available were excluded. Our center is one of the largest tertiary care centers in the region, and patients continued postoperative follow-up in the centers from which they were referred. Therefore, in some cases, obtaining Holter ECG records were difficult.

Statistical Analysis

The data were analyzed using SPSS version 21.0 (IBM Corp, Armonk, NY, USA). The Kolmogorov–Smirnov test was used to test whether the data were homogeneously distributed. Comparisons of data from two independent groups were performed using Student's t test for homogeneous data and Mann–Whitney U test for nonhomogeneous data. To compare group ratios, the chi-square test was used. Comparisons with P <0.05 were considered statistically significant.

Results

Of the 250 patients who underwent transcatheter closure, 154 (61.6%) were female and 96 (38.4%) were male. The mean age at angiography was 8.03 ± 3.8 years, and the mean weight was 28.9 ± 15.7 kg. Defect diameter measured transthoracically or transesophageally ranged from 7 to 25 mm, with a mean of 12.3 ± 4.1 mm. The catheterization-derived mean pulmonary artery pressure was 14.1 ± 4.0 mmHg, and the mean Qp/Qs ratio was 1.93 ± 0.55.

Of the 177 patients who underwent surgical closure, 104 (58.8%) were female and 73 (41.2%) were male. The mean age at surgery was 7.01 ± 4.2 years, and the mean weight was 24 ± 16.1 kg. Defect diameters measured transthoracically or transesophageally were 8–37 mm, with a mean of 18 ± 5.7 mm. Mean cardiopulmonary bypass and aortic

cross-clamp times were 24.31 ± 7.96 min and 51.58 ± 13.8 min, respectively.

After transcatheter closure, follow-up basal ECG showed an incomplete right bundle branch block pattern in 21 patients and sinus rhythm in 229 patients. After surgical closure, the incomplete right bundle branch block pattern was detected in 23 patients, a complete right bundle branch block in three patients, and a complete AV block pattern in one patient. The other 150 patients showed sinus rhythm. An incomplete right bundle branch block is a common ECG finding of ASD and has been shown to persist after the procedure in patients. This rhythm disturbance was not considered a newly developed rhythm disorder after ASD closure.

At least one postoperative follow-up Holter ECG record could be obtained for 104 patients in the transcatheter group and 96 patients in the surgical group. Patients whose Holter ECG records were not accessible were excluded from the evaluation. The follow-up period of the patients is between 2 and 14 years. Routine Holter ECG monitoring is performed every 2 years for our patients who are followed up in our clinic. Holter ECG changes have been noted. The patients who were found to have extrasystole during the follow-up did not need electrophysiological studies. Only medical treatment was administered.

Figure 1 shows rhythm disturbances detected in the patients' Holter ECG records. Of 104 patients who underwent transcatheter closure, 97 (93.3%) had normal Holter ECG findings and 7 (6.7%) had arrhythmia. Of the 96 patients who underwent surgical closure, 85 (88.5%) had normal Holter ECG traces and 11 (11.5%) had arrhythmia. There was no statistically significant difference in the frequency of arrhythmia (P = 0.164). Long QT syndrome and Wolff–Parkinson–White (WPW) syndrome were present in patients before ASD closure, and these rhythm disturbances were not associated with the previous surgical procedure.

A comparison of transcatheter closure patients with normal Holter ECG and those with arrhythmia revealed no significant differences in terms of sex, age, weight, ASD diameter, mean pulmonary artery pressure, or Qp/Qs ratio.

A comparison of surgical closure patients with normal Holter ECG and arrhythmia showed no significant difference between the two groups in terms of sex or cardiopulmonary bypass and aortic clamp times. Nevertheless, statistically significant differences were found in age, weight, and ASD diameter (P <0.05). The frequency of arrhythmia was positively associated with the patient's age, weight, and ASD diameter.

In the transcatheter closure group, three patients developed transient supraventricular tachycardia (SVT), and two patients developed first-degree AV block during the proce-

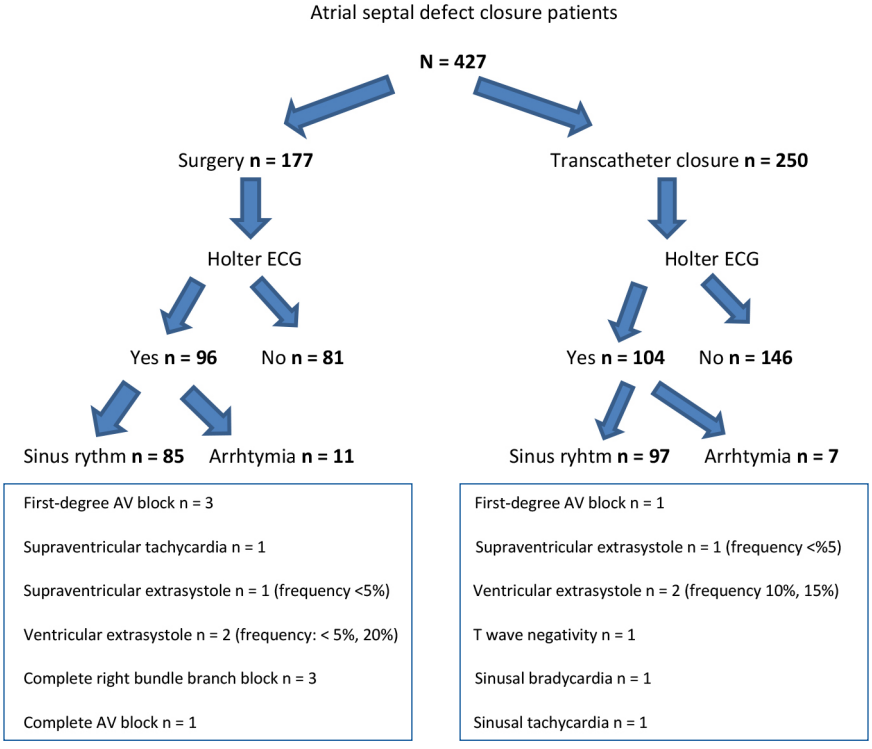

Figure 1. Evaluation of arrhythmia frequencies with Holter ECG in transcatheter and surgically closed secundum atrial septal defect patients.

dure. The patients who developed SVT were treated with adenosine, and all patients returned to sinus rhythm. The first-degree AV block resolved spontaneously. Atrial extrasystoles occurring at the time of device deployment were not hemodynamically significant and were not considered an arrhythmia complication if transient.

In both groups, patients with a history of SVT received beta-blocker therapy (metoprolol or propronolol). Propronolol was initiated in a patient with long QT syndrome. A patient with WPW syndrome was referred to the electrophysiology center for catheter ablation, which was performed successfully. Patients with ventricular and supraventricular extrasystoles were managed via clinical observation or medical treatment (beta-blocker) according to extrasystole frequency. A permanent pacemaker was implanted in the patient who developed a complete AV block.

Discussion

ASD is one of the most common congenital heart disorders and can be treated via transcatheter or surgical closure.[8] Compared with surgical closures, transcatheter closures are reported to be less traumatic, have a faster recovery process, and cause fewer complications. Despite the advantages of transcatheter closure, the complication rate may increase due to inappropriate patient selection, wrong choice of procedure, and lack of experience. Arrhythmia is one of the most common complications after both closure methods.[9]

Although atrial and sinoatrial/AV node arrhythmias are generally associated with ASD in adults, such arrhythmias are generally much less common in the pediatric age group. Studies have shown that the risk factors for the development of arrhythmia include defect diameter, age at surgery, amount of shunt, and comorbid diseases and that arrhythmia may also occur spontaneously independent of the procedure.[10] Arrhythmia before closure increases the risk of arrhythmia after ASD closure. Published pediatric studies have indicated that the frequency of arrhythmias increases with a high mean PAP, a device >19 mm, a device/body size ratio >0.2, and a high Qp/Qs ratio.[11]

Many studies are reporting the development of arrhythmias after transcatheter ASD closure.[12,13] Sinus bradycardia, SVT, premature atrial beats, AV block, and atrial fibrillation are the most common types of arrhythmias reported.[9] Consistent with the literature, sinus bradycardia, SVT, first-degree AV block, and sinus tachycardia were observed in our study. Unlike the literature, ventricular extrasystole and T wave intervision on V4, V5, and V6 were detected in one patient. Although atrial flutter and fibrillation are common in the literature, they were not detected in our study. The low frequency of atrial arrhythmia among our patients may be related to the low mean age and early ASD closure. Atrial fibrillation and atrial flutter are mostly seen in patients who undergo transcatheter closure in adulthood.[14,15]

There are also studies reporting arrhythmias that develop after surgical ASD closure.[16,17] The most commonly reported types of arrhythmia are sinoatrial premature beats, atrial fibrillation, and atrial flutter. The risk of arrhythmia increases with older age and longer aortic clamp and cardiopulmonary bypass time.[18] Permanent complete heart block is a significant complication of intracardiac repair for congenital heart disease. It refers to a postoperative heart block that does not spontaneously revert to the preoperative rhythm (usually within 10 days of the operation). Dexamethasone is recommended at 0.4 mg/kg per day for 5–7 days. Meanwhile, patients were monitored with a temporary pacemaker. In our study group, a permanent pacemaker was implanted in a patient who developed a complete AV block.

The incidence of arrhythmia in surgical patients increased in association with defect diameter, age, and weight, which is consistent with the literature. However, we observed no statistically significant difference between patients with and without arrhythmia in terms of cardiopulmonary bypass or aortic clamp time.

Although normal findings or right bundle branch block with right axis deviation on ECG are considered signs of ASD, it has been claimed in electrophysiology studies that there is no real electrical delay and that the block is mostly due to volume load. There are reports of branch blocks persisting after the procedure.[19,20] In our study, 44 patients had incomplete right bundle branch blocks, and three patients had complete right bundle branch blocks. As stated in previous studies, the higher incidence of right bundle branch blocks in surgical patients may be attributable to the surgical incision, as well as the greater volume load on the right ventricle in the preoperative period. This theory is supported by the larger ASD diameter and amount of shunt in the patients who underwent surgical closure.

The transcatheter and surgical groups showed no difference in the frequency of arrhythmia. Although patients who underwent surgical closure had larger and more hemodynamically significant ASDs, difference in terms of arrhythmia development was not found during follow-up. None of the patients in either group developed a life-threatening arrhythmia that required cardioversion. A meta-analysis of adult ASD patients who underwent surgical and transcatheter closure included cases with arrhythmias that require cardioversion.[20]

Hemodynamic parameters were evaluated via right heart catheterization in patients who underwent transcatheter

closure, but right heart catheterization was not performed in patients undergoing surgical closure in our center. The decision to perform surgery was made based on the patients' echocardiographic measurements. In the surgical closure group, elevated pulmonary arterial pressure was decided only via echocardiographic findings without performing a transcatheter measurement.

The higher frequency of arrhythmia in studies involving adults in comparison with the pediatric age group once again demonstrates the importance of early diagnosis and treatment of ASD in childhood. The similar incidence of arrhythmia in both groups supports the safety and effectiveness of both closure methods in eligible patients.

Ethics Committee Approval: This study was approved by the Dr. Behçet Uz Pediatrics Hospital Ethics Committee (Decision no: 495; Evaluation date: 28.01.2021).

Informed Consent: Written informed consent was obtained from the participants of this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - E.D., M.M.Y.; Design - E.G., G.V.; Supervision - T.M.; Data Collection and/or Processing - U.K., E.D., M.K.; Analysis and/or Interpretation - C.K., C.Z., M.M.; Literature Search - E.D.; Writing Manuscript - E.D.; Critical Review - M.M.Y., T.M.

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