Advanced Medical Journal, Vol.11, No.2, P.193-202,2026 https://doi.org/10.56056/amj.2026.475

Immediate and Short-Term Outcomes of Transcatheter VS Surgical Closure of Secundum Atrial Septal Defect in Erbil Surgical Specialty Hospital/Cardiac Center

Zahrah Jamal Hamad* Aso Faeq Salih Zuhair Ibrahim Al-Nasiry*****

Abstract

Introduction: The secundum atrial septal defect is a common congenital heart disease in children and adolescents. This study set out to compare transcatheter closure versus surgical closure for secundum atrial septal defect in children and adolescents in terms of immediate and short-term results of.

Methods: A prospective interventional study conducted in Surgical Specialty hospital-Erbil cardiac center in Erbil city-Kurdistan region/Iraq in duration of twelve months 1st of April 2023 to 31st of March 2024 on sample of 50 children with secundum atrial septal defect divided into two study groups (25 children underwent transcatheter intervention and 25 children underwent surgical intervention). Post procedure outcomes (Heart rate, ECG changes, complications, hospital stay duration) were assessed.

Results: In both study groups, the means of vital signs were significantly reduced after 3 months from intervention ($p<0.001$). After 3 months, the means of heart rate and QRS duration were not significantly different between two study groups ($p>0.05$), while means of p wave minimum, p wave maximum, p wave dispersion and PR interval were significantly lower among children underwent transcatheter intervention ($p\leq0.05$). There was a highly a significant association between longer hospital stay and children underwent surgical intervention ($p<0.001$).

Conclusion: Both transcatheter and surgical closure of secundum atrial septal defect are effective, but the transcatheter intervention is associated with less immediate complications and shorter hospital stay duration.

Keywords: Atrial septal defect, Echocardiogram, Transcatheter, Surgery

*MBChB, M.B.Ch.B, FKBMS (Ped), Pediatric Cardiology. Surgical Specialty Hospital-Erbil Cardiac Center-Erbil City-Kurdistan Region/Iraq. Email: Zahra.jamal89@yahoo.com, Corresponding Author.
**M.B.Ch.B, DCH, FIBMS, FACC, MSc Pediatric Cardiology; Professor in Pediatric Cardiology; Sulaimanyah Center- Sulaimanyah City-Kurdistan Region/Iraq.
***M.B.Ch.B, D.M,MSc Pediatric Cardiology; Surgical Specialty Hospital-Erbil Cardiac Center-Erbil City-Kurdistan Region/Iraq.

Introduction

The atrial septal defect (ASD) is a common congenital heart disease detected in about one-fourth of children.[1] The ASD is recognized as failed in closing the connection between right and left heart atria caused by defective true septal membrane or other defects. It is composed of 5 types commonly; patent foramen ovale, ostium secundum defect, ostium primum defect, sinus venosus defect and coronary sinus defect.[2] Atrial septal defects with small size will close spontaneously, while those with large size may need trans-catheter or surgical management in order to prevent future co-morbidities like stroke, dysrhythmias and pulmonary hypertension.[3] The secundum atrial septal defect (ASD II) is a prevalent type of ASD with prevalence of 164 in 100,000 live births and high incidence among premature children.[4] Most cases of ASD II are asymptomatic in early childhood, while small size asymptomatic ASD II closes spontaneously.[5] Generally, the ASD constituted a global prevalence of 1.6/1000 live births and global incidence rate of 56/100,000 live births.[6,7] On echocardiography, ASD incidence rate reached to 100/100,000 live births.[7] The interventional ASD closure is essential for asymptomatic children with remarkable hemodynamic shunt at early childhood.[8] The life expectancy of children with ASD is lower than normal children.[9] Heart failure symptoms, failure to thrive and high infection incidence rates might clarify the need for early interventional closure.[10] Many authors found that prematurity of infants delayed spontaneous closure of ASD.[11,12] Moreover, atrial shunt might negatively affect the pulmonary hypertension.[13-15] Interventional closure by surgery is efficient treatment for ASD accompanied by low death rate in children without co-morbidities and long life expectancy especially if done at earlier age.[17] Interventional closure by trans-catheter is the treatment of choice for children with secundum ASD, with equal efficacy of surgical intervention.[18,19] Fortunately, the trans-catheter interventional ASD closure is safe, preventing different postoperative complications of surgical intervention like anesthesia, thoracotomy, cardiopulmonary bypass and also accompanied with short length of hospital stay.[20] However, the trans-catheter ASD closure is complicated by device embolization that needs surgical intervention, in addition to rare cardiac erosion or perforation and infection with future endocarditis, allergy and thrombus formation.[21,22] The aim of this study was to assess transcatheter closure of secundum ASD in children and adolescents in terms of immediate and short-term outcomes, comparing its safety and effectiveness with surgical repair. It also focused on evaluating how the heart's electrical activity remodels following both transcatheter and surgical ASD closure, all within a single institution.

Patients and methods

A prospective interventional study conducted in Surgical Specialty hospital-Erbil cardiac center in Erbil city-Kurdistan region/Iraq in duration of twelve months from 1st of April 2023 to 31st of March 2024. The selected sample size was 50 children with secundum ASD divided into two study groups (25 children underwent transcatheter intervention and 25 children underwent surgical intervention). All children with atrial septal defect (ASD) presented to cardiac center for management were the study population. The study included children and adolescents aged 2 to 17 years with secundum ASD. For the device group, the ASD diameter measured by echocardiography ranged from 8 mm to 38 mm, while there was no size limit for the surgical group. Additional criteria included the presence of right ventricular volume overload (categorized into mild moderate and severe according to Feigenbaum et al.) with a left-to-right shunt, a minimal shunt

https://doi.org/10.56056/amj.2026.475

accompanied by symptoms such as arrhythmias or transient ischemic attacks, and a distance of more than 5 mm between the ASD margins and the superior vena cava (SVC), inferior vena cava (IVC), atrioventricular valves, and right upper pulmonary vein, as determined by echocardiography.[23,24] Exclusion criteria for the study included children weighing less than 8 kg, those with additional congenital heart defects requiring surgery, and patients with a right-to-left atrial shunt causing peripheral oxygen saturation below 94%. The study also excluded patients with other types of ASD, such as primum ASD or sinus venosus ASD (including cases with partial anomalous pulmonary venous drainage), multiple defects that could not be effectively treated with a device, and situations where parents declined to participate in the study. Information of patients was acquired directly with interviewing them or from their parents and saved in a well-designed questionnaire that was included general characteristics of patients (age, sex, weight and presentation), intervention type, vital signs , Electrocardiography and transthoracic echocardiography (type of intra-atrial septum defect, ASD diameter by Transthoracic Echocardiogram (TTE) , right side volume load, mitral valve abnormalities and mitral regurgitation) and outcome of each procedure (immediate complications such as bleeding from the site of intervention, residual shunt, air embolism new valve insufficiency, arrhythmias, and stroke; complications during follow up such as pleural effusion, wound infection, pericardial effusion and length of hospital stay). Vital signs were measured by nurse on call in pediatric ward and in ICU and all investigations were done in Surgical Specialty hospital-Erbil cardiac center. All patients underwent full echocardiographic study at baseline and during follow up using (GE Vivid E9) echocardiography machine, 5 and 6 transducer probes. The diagnosis of ASD secundum was made using 2D echocardiography with Doppler and color imaging, capturing detailed views from the parasternal, subxiphoid, and apical angles. This approach allowed for a precise assessment of the ASD's size, surrounding structures, morphological characteristics, and the rims of the defect. A standard 12-lead electrocardiogram (ECG) was taken for all patients, both at the beginning of the study and during follow-up visits, using a paper speed of 25 mm/s and a calibration of 1 mV/cm.The measurements for the P wave, PR interval, and QRS duration were taken as follows: P wave was measured from the start, where the P wave begins to rise from the isoelectric line, to the end, where it returns to the isoelectric line after the deflection. In any of the 12 ECG leads, the shortest duration was noted as the P wave minimum (P min), while the longest duration of the P wave was recorded as the P wave maximum (P max). P wave dispersion (P dis) was calculated by taking the difference between the longest P wave duration (P max) and the shortest (P min). The PR interval was measured from the onset of the P wave to the start of the QRS complex. QRS duration was defined as the time from the beginning to the end of the QRS complex in any lead, specifically measuring the interval from the first to the last sharp deflection crossing the isoelectric line.[25] Percutaneous transcatheter ASD closure was carried out under general anesthesia when the anatomical features and surrounding rims of the defect were suitable. The procedure was guided by fluoroscopy and transesophageal echocardiography (TEE), using the Amplatzer septal occluder (ASO) device. The success of the device placement was confirmed by checking for any significant leakage and through transthoracic echocardiography (TTE). For patients whose defects were not appropriate for transcatheter closure, surgical closure was

https://doi.org/10.56056/amj.2026.475

performed using a patch technique. Follow up of each individual patient was on 24 hours after procedure and 3 months after procedure by means of clinical assessment, 12 lead ECG and echocardiography. Ethics of study was implemented in regard to Ethical Committee of Kurdistan Higher Council for Medical Specializations with consent of parents and continuing their monitoring and management. The study statistics was accomplished through using statistical package of social sciences, version 26 and apply of chi-square or fissures exact tests for categorical variables with level of significance was put at <0.05.

Results

This study included 50 children with secendum ASD divided into two study groups (25 children underwent transcatheter intervention and 25 children underwent surgical intervention). The mean weight of the patients underwent transcatheter intervention was 28.6±11.3 and those underwent surgical intervention was 29.1±12.7. Majority of patients (84% of transcatheter and 76% of surgical group) were asymptomatic and referred to our department because of an incidentally detected heart murmur. No significant differences were observed between children of both study groups regarding general characteristics (p>0.05), Table (1).

Table (1): Distribution of children's general characteristics according to study groups

Variable	Intervention type				P
	Transcatheter		Surgical		
	No.	%	No.	%	
Age					0.13 NS
<5 years	3	12.0	6	24.0	
5-10 years	16	64.0	9	36.0	
11-17 years	6	24.0	10	40.0	
Sex					0.5 NS
Male	11	44.0	9	36.0	
Female	14	56.0	16	64.0	
Weight (Kg)	28.6±11.3		29.1±12.7		0.8
Presentation					0.3 NS
Asymptomatic	21	84.0	19	76.0	
Palpitation	4	16.0	4	16.0	
Frequent respiratory tract infection	0	-	2	8.0	

NS=Not significant, S=Significant.

There were no significant differences between both study groups regarding type of IAS defect, ASD diameter by TTE, mitral valve abnormalities. The mean ASD diameter for transcatheter group was 18.28 mm and for surgical group was 23.36 mm. A significant difference between study groups was observed in regard to right side volume load (p=0.01); no children underwent transcatheter with severe right side volume load, while 28% of children underwent surgery had severe right side volume load Table (2).

Table (2): Distribution of pre-procedure transthoracic echocardiography in regard to study groups

Variable	Intervention type				P
	Transcatheter		Surgical		
	No.	%	No.	%	
Right side volume load					0.01 S
Mild	8	32.0	4	16.0	
Moderate	17	68.0	14	56.0	
Severe	0	-	7	28.0	
Type of IAS defect					0.32 NS
Single defect	25	100.0	22	88.0	
Multiple fenestrated	0	-	1	4.0	
Aneurysmal	0	-	2	8.0	
ASD diameter by TTE					0.07 NS
8-18 mm	13	52.0	10	40.0	
19-29 mm	12	48.0	9	36.0	
30-38 mm	0	-	5	20.0	
≥39 mm	0	-	1	4.0	

https://doi.org/10.56056/amj.2026.475

Mitral valve abnormalities					0.14 NS
No	23	92.0	25	100.0	
Yes	2	8.0	0	-	

NS=Not significant, S=Significant.

Before the intervention, the average heart rate, P wave dispersion, and QRS duration were similar between the two study groups (p>0.05). However, children who underwent surgical intervention had significantly higher means for P wave minimum, P wave maximum, and PR interval compared to those who received transcatheter treatment (p≤0.05). At 24 hours and on 3 months follow up visit the means of heart rate and QRS duration were not significantly different between two study groups (p>0.05), while means of p wave minimum, p wave maximum, p wave dispersion and PR interval were significantly lower among children underwent transcatheter intervention (p≤0.05) Table (3).

Table (3): Distribution of electrocardiographic parameters at different periods in regard to study groups

Variable	Intervention type		P
	Transcatheter	Surgical	
	Mean±SD	Mean±SD	
Before procedure			
Heart rate (b/m)	92.7±11.1	95.2±13.3	0.5 NS
P min (msec.)	76.9±9.5	87±7.6	<0.001 S
P max (msec.)	114.6±10.4	127.6±10.1	<0.001 S
P dis (msec.)	37.6±4.7	40.6±7.4	0.09 NS
PR interval (msec.)	157.6±13.7	169.4±14.3	0.005 S
QRS duration (msec.)	94.1±7.3	98.3±11.1	0.1 NS
After 24 hours			
Heart rate (b/m)	89.7±6.5	89.5±6	0.9 NS
P min (msec.)	72.1±8	83.4±6.9	<0.001 S
P max (msec.)	96.8±9.7	113±8.7	<0.001 S
P dis (msec.)	24.7±3.5	29.6±5.3	<0.001 S
PR interval	143.7±12.9	157.6±13.7	0.001 S
QRS duration	88.7±6.3	93.1±10.6	0.08 NS
After 3 months			
Heart rate (b/m)	84.9±3.7	85.1±5.3	0.9 NS
P min (msec.)	67.6±7.4	79.7±6.4	<0.001 S
P max (msec.)	89.7±8.3	106.5±8.7	<0.001 S
P dis (msec.)	22.1±2.5	26.8±4.7	<0.001 S
PR interval	132.5±12.3	146.2±13.2	<0.001 S
QRS duration (msec.)	85.1±5.6	86.6±6.2	0.3 NS

NS=Not significant, S=Significant.

The means of heart rate (HR), QRS duration, PR interval, p min, p max, p dis, and of children were significantly reduced after 3 months from transcatheter intervention (p<0.001). The means of HR, p max, p min, p wave dispersion, QRS duration and PR interval of children were significantly reduced after 3 months from surgical intervention (p<0.001) Table (4). The immediate complication was significantly higher among children underwent surgical intervention than transcatheter intervention (p=0.03). There were no significant differences between both study groups regarding complications during follow up. There was a highly a significant association between longer hospital stay and children underwent surgical intervention (p<0.001) Table (5).

https://doi.org/10.56056/amj.2026.475

Table (4): Distribution of study groups electrocardiographic parameters before and after intervention

Variable	Before	After 24 hrs	After 3 months	P
	Mean±SD	Mean±SD	Mean±SD	
Transcatheter				
Heart rate (b/m)	92.7±11.1	89.7±6.5	84.9±3.7	<0.001 S
P wave minimum (msec.)	76.9±9.5	72.1±8	67.6±7.4	<0.001 S
P wave maximum (msec.)	114.6±10.4	96.8±9.7	89.7±8.3	<0.001 S
P wave dispersion (msec.)	37.6±4.7	24.7±3.5	22.1±2.5	<0.001 S
PR interval (msec.)	157.6±13.7	143.7±12.9	132.5±12.3	<0.001 S
QRS duration (msec.)	94.1±7.3	88.7±6.3	85.1±5.6	<0.001 S
Surgical				
Heart rate (b/m)	95.2±13.3	89.5±6	85.1±5.3	<0.001 S
P wave minimum (msec.)	87±7.6	83.4±6.9	79.7±6.4	<0.001 S
P wave maximum (msec.)	127.6±10.1	113±8.7	106.5±8.7	<0.001 S
P wave dispersion (msec.)	40.6±7.4	29.6±5.3	26.8±4.7	<0.001 S
PR interval (msec.)	169.4±14.3	157.6±13.7	146.2±13.2	<0.001 S
QRS duration (msec.)	98.3±11.1	93.1±10.6	86.6±6.2	<0.001 S

Table (5): Distribution of outcomes in regard to study groups

Variable	Intervention type				P
	Transcathete		Surgical		
	No.	%	No	%	
Immediate complications					0.03 S
Yes	3	12.0	6	24.0	
No	22	88.0	19	76.0	
Complications during follow up					0.3 NS
Yes	1	4.0	0	-	
No	24	96.0	25	100.0	
Length of hospital stay					<0.001 S
1-2 days	24	96.0	0	-	
3-4 days	0		0	-	
5-7 days	1	4.0	25	100.0	

NS=Not significant, S=Significant

ASD device closure was successful in all patients, there were no bleeding from the site of intervention, no arrhythmias, no air embolism, no stroke, only two patients had trivial residual shunting which was not evident at 24 hours follow up and one patient had new mitral valve insufficiency, Figure (1).

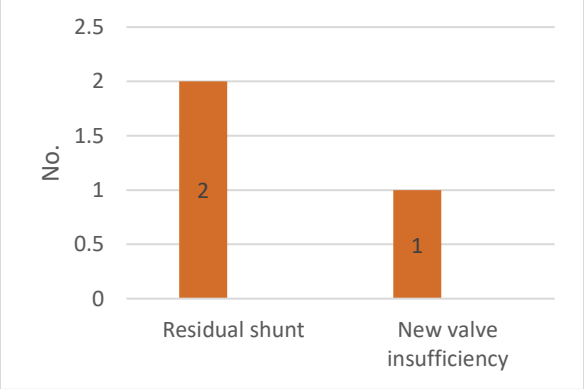

Figure (1): Immediate complications of transcatheter intervention.

https://doi.org/10.56056/amj.2026.475

The immediate complications of surgical interventions were mild pleural effusion (8%), trace pericardial effusion (2%) and wound infection (2%) which all resolved during period of hospital stay and none of them needed any intervention, Figure (2).

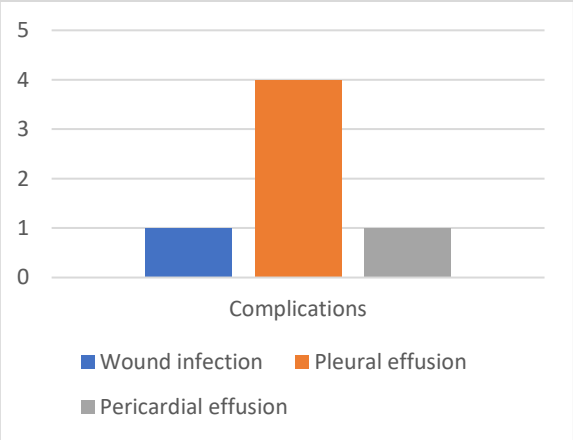

Figure (2): Immediate complications of surgical intervention.

Discussion

This study demonstrated that the mean HR, P wave minimum, P wave maximum, P wave dispersion, QRS duration, and PR interval in children with secundum ASD significantly decreased three months after transcatheter intervention. Similarly, other studies have documented the effectiveness of transcatheter intervention in reducing the risk of arrhythmias in children with secundum ASD following defect closure.[26] Our study also found that the mean HR, PR interval, QRS duration, p wave minimum, p wave maximum, and p wave dispersion were significantly reduced three months after surgical intervention. This finding aligns with Talwar et al.'s study, which reported the effectiveness of surgical closure of secundum ASD in preventing arrhythmias among children.[27] However, our study found no significant difference in mean heart rate and QRS duration between the two groups after three months, while the means of p wave minimum, p wave maximum, p wave dispersion, and PR interval were significantly lower in children who underwent transcatheter intervention compared to surgery. These findings are consistent with Mansour et al.'s prospective study, which reported greater effectiveness of transcatheter intervention in preventing arrhythmias than surgical intervention.[28] The current study found a significant relationship between severe right-sided volume load and children with secundum ASD who underwent surgery. Consistent with this, Du et al.'s multicenter non-randomized study, found that children with secundum ASD who underwent surgical intervention had a higher prevalence of severe right-sided volume load compared to those who underwent transcatheter intervention.[29] Our study also found that immediate complications were significantly higher among children with secundum ASD who underwent surgical intervention than those who had transcatheter intervention. This is in line with Siddiqui et al.'s review study, from developing countries, which reported that both transcatheter and surgical interventions effectively closed secundum ASD, but with fewer immediate complications among children who underwent transcatheter intervention.[30] In our study, there were no significant differences between transcatheter and surgical interventions regarding complications during follow-up. This result is congruent to the results of Saleem et al.'s prospective comparative study, which revealed that the short-term complications of transcatheter and surgical interventions in children with secundum ASD are comparable.[31] However, our study revealed a significant correlation between extended hospital stays and children who underwent surgical intervention. This finding is consistent with Askari et al.'s single-center retrospective cohort study, in Iran, which showed that both transcatheter and surgical interventions are effective in closing secundum ASD, but with higher

https://doi.org/10.56056/amj.2026.475

short-term complication rates and longer hospital stays in children who underwent surgical intervention.[32] The current study reported that the immediate complications of transcatheter interventions included bleeding and hematoma (4%), residual shunt (4%), pericardial effusion (2%), and new valve insufficiency (2%). These results are in agreement with Bartakian et al.'s retrospective study.[33] Our study also found that the immediate complications of surgical interventions included pleural effusion (10%), pleural and pericardial effusion (8%), wound infection (2%), and pericardial effusion (8%). These results are consistent with the findings of Kodaira et al.'s retrospective study conducted in a single-center.[34]

Conclusion

Both transcatheter and surgical interventions for closing secundum ASD are effective, but transcatheter intervention is associated with fewer immediate complications, shorter hospital stays, and faster cardiac electrical remodeling. This study recommends earlier transcatheter intervention for patients who are indicated.

Conflict of interest

None.

Acknowledgment

Special regards for medical staff working in Cardiac center.

References

1. Bradley EA, Zaidi AN. Atrial Septal Defect. Cardiol Clin 2020; 38(3):317-324.
2. Celermajer DS. Atrial septal defects: even simple congenital heart diseases can be complicated. Eur Heart J 2018; 39(12):999-1001.
3. Fraisse A, Latchman M, Sharma SR, Bayburt S, Amedro P, di Salvo G, et al. Atrial septal defect closure: indications and contra-indications. J Thorac Dis 2018; 10(Suppl 24): S2874-S2881.
4. Giang KW, Mandalenakis Z, Fedchenko M, Eriksson P, Rosengren A, Norman M, et al. Congenital heart disease: Changes in recorded birth prevalence and cardiac interventions over the past half-century in Sweden. Eur J Prev Cardiol 2023; 30(2):169–176.
5. Naqvi N, McCarthy KP, Ho SY. Anatomy of the atrial septum and interatrial communications. J Thorac Dis 2018; 10(Suppl 24): S2837–S2847.
6. Kuijpers JM, Mulder BJ, Bouma BJ. Secundum atrial septal defect in adults: A practical review and recent developments. Neth Heart J 2015; 23: 205–211.
7. Geva T, Martins JD, Wald RM. Atrial septal defects. Lancet 2014; 383: 1921–1932.
8. Torres AJ. Hemodynamic assessment of atrial septal defects. J Thorac Dis 2018; 10(Suppl 24): S2882–S2889.
9. Nyboe C, Karunanithi Z, Nielsen-Kudsk JE, Hjortdal VE. Long-term mortality in patients with atrial septal defect: A nationwide cohort-study. Eur Heart J 2018; 39(12):993–998.
10. Feltes TF, Bacha E, Beekman RH, 3rd, Cheatham JP, Feinstein JA, Gomes AS, et al. Indications for cardiac catheterization and intervention in pediatric cardiac disease: A scientific statement from the American Heart Association. Circulation 2011; 123(22):2607–2652.
11. Riggs T, Sharp SE, Batton D, Hussey ME, Weinhouse E. Spontaneous closure of atrial septal defects in premature versus full-term neonates. Pediatr Cardiol 2000; 21(2):129–134.
12. Hanslik A, Pospisil U, Salzer-Muhar U, Greber-Platzer S, Male C. Predictors of spontaneous closure of isolated secundum atrial septal defect in children: A longitudinal study. Pediatrics 2006; 118(4):1560–1565.
13. Vyas-Read S, Guglani L, Shankar P, Travers C, Kanaan U. Atrial septal defects accelerate pulmonary hypertension diagnoses

https://doi.org/10.56056/amj.2026.475

in premature infants. Front Pediatr 2018; 6:342.
14. Triedman JK, Newburger JW. Trends in Congenital Heart Disease: The Next Decade. Circulation 2016; 133: 2716–2733.
15. Engelings CC, Helm PC, Abdul-Khaliq H, Asfour B, Bauer UM, Baumgartner H, et al. Cause of death in adults with congenital heart disease—An analysis of the German National Register for Congenital Heart Defects. Int J Cardiol 2016; 211: 31–36.
16. Pei L, Kang Y, Zhao Y, Yan H. Prevalence and risk factors of congenital heart defects among live births: A population-based cross-sectional survey in Shaanxi province, Northwestern China. BMC Pediatr 2017; 17: 18.
17. Kuijpers JM, van der Bom T, van Riel AC, Meijboom FJ, van Dijk AP, Pieper PG, et al. Secundum atrial septal defect is associated with reduced survival in adult men. Eur Heart J 2015; 36(31):2079-2086.
18. Akagi T. Current concept of transcatheter closure of atrial septal defect in adults. J Cardiol 2015; 65(1):17-25.
19. Kutty S, Hazeem AA, Brown K, Danford CJ, Worley SE, Delaney JW, et al. Long-term (5- to 20-year) outcomes after transcatheter or surgical treatment of hemodynamically significant isolated secundum atrial septal defect. Am J Cardiol 2012; 109(9):1348-1352.
20. Ooi YK, Kelleman M, Ehrlich A, Glanville M, Porter A, Kim D, et al. Transcatheter Versus Surgical Closure of Atrial Septal Defects in Children: A Value Comparison. JACC Cardiovasc Interv 2016; 9(1):79-86.
21. Moore J, Hegde S, El-Said H, Beekman R 3rd, Benson L, Bergersen L, et al; ACC IMPACT Steering Committee. Transcatheter device closure of atrial septal defects: a safety review. JACC Cardiovasc Interv 2013; 6(5):433-442.
22. O'Byrne ML, Glatz AC, Gillespie MJ. Transcatheter device closure of atrial septal defects: more to think about than just closing the hole. Curr Opin Cardiol 2018; 33(1):108-116.
23. Feigenbaum H, Armstrong W, Ryan TArmstrong W. Echocardiographic assessment of the interatrial septal defect Feigenbaum's Echocardiography. 6th ed. 2005. Philadelphia, PA Lippincott.
24. Chambault A-L, Olsen K, Brown LJ, Mellor SL, Sorathia N, Thomas AE, et al. Transcatheter versus surgical closure of atrial septal defects: a systematic review and meta-analysis of clinical outcomes. Cardiology in the Young. 2022;32(1):1–9. doi:10.1017/S1047951121004583/
25. How to measure the PR interval. My EKG. Available from: https://en.my-ekg.com/how-read-ekg/pr-interval.html/
26. Jalal Z, Hascoet S, Baruteau AE, Iriart X, Kreitmann B, Boudjemline Y, et al. Long-term Complications after Transcatheter Atrial Septal Defect Closure: A Review of the Medical Literature. Can J Cardiol 2016; 32(11): 1315.e11-1315.e18.
27. Talwar S, Patel K, Juneja R, Choudhary SK, Airan B. Early postoperative arrhythmias after pediatric cardiac surgery. Asian Cardiovascular and Thoracic Annals 2015; 23(7):795-801.
28. Mansour NM, Ghonimy El Sheikh R, Elsaeid AM, El-setiha ME, Badr SF. Factors determining occurrence of arrhythmias in patients postclosure of atrial septal defects. J Saudi Heart Assoc. 2021; 33 (3):221-227. Available from: https://doi.org/10.37616/2212-5043.1260/
29. Du ZD, Hijazi ZM, Kleinman CS, Silverman NH, Larntz K; Amplatzer Investigators. Comparison between transcatheter and surgical closure of secundum atrial septal defect in children and adults: results of a multicenter nonrandomized trial. J Am Coll Cardiol 2002; 39(11):1836-1844.

30. Siddiqui WT, Usman T, Atiq M, Amanullah MM. Transcatheter versus surgical closure of atrial septum defect: a debate from a developing country. J Cardiovasc Thorac Res 2014; 6(4):205-210.
31. Saleem S, Younas M, Asma T, Riaz U, Tousif R, Maqbool B. Comparison of Short-Term Outcomes of Transcatheter versus Surgical Closure of Atrial Septum Defect at a Tertiary Cardiac Care Facility. PAFMJ 2023; 73(3): 837–40. Available from: https://doi.org/10.51253/pafmj.v73i3.8633/
32. Askari B, Soraya H, Ayremlu N, Golmohammadi M. Short-term outcomes after surgical versus trans catheter closure of atrial septal defects; a study from Iran. Egypt Heart J 2018; 70(4):249-253.
33. Bartakian S, Fagan TE, Schaffer MS, Darst JR. Device closure of secundum atrial septal defects in children <15 kg: complication rates and indications for referral. JACC Cardiovasc Interv 2012; 5(11):1178-1184.
34. Kodaira M, Kawamura A, Okamoto K, Kanazawa H, Minakata Y, Murata M, et al. Comparison of Clinical Outcomes After Transcatheter vs. Minimally Invasive Cardiac Surgery Closure for Atrial Septal Defect. Circ J 2017; 81(4):543-551.

https://doi.org/10.56056/amj.2026.475