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Evaluation of Clinical Course in Children and Adolescents with Atrial Septal Defects

Noor Mohammad Noori[1], *Alireza Teimouri[2]

[1]Pediatric Cardiologist, Children and Adolescent Health Research Center, Resistant Tuberculosis Institute, School of Medicine, Zahedan University of Medical Sciences, Zahedan 9816743111, Iran.

[2]M.Phil, PhD in Demography, Children and Adolescent Health Research Center, Resistant Tuberculosis Institute, School of Medicine, Zahedan University of Medical Sciences, Zahedan 9816743111, Iran.

Abstract

Background

Atrial septal defects (ASDs) are the most common third congenital heart defects. This study aimed to evaluate the clinical course of ASDs and the relationship between its complications, location closure and size.

Materials and Methods: This cross-sectional study was conducted in the cardiac center of the pediatric ward in Zahedan, Iran. The study was carried out on 529 children with ASD between 2003 and 2018. The ASD children underwent echocardiography and complete examination such as physical exams, ECG and chest X-ray at every visit during follow-up. A diagnosis of ASDs was confirmed by a transthoracic echocardiography. A unique cardiologist applied transthoracic echocardiography to get information about size, location, and the number of the defects as well as hemodynamic information such as pulmonary artery pressure and any associated lesions. The data were analyzed using SPSS software version 20.0.

Results: From 529 ASD children, 278 (52.5%) were girls. Most were medium (46.1%). 44.2% were closed by surgery; about 90.9% were secundum. 133 closed spontaneously and 14.6% by device. ASDs size had significant association with closure, location, and complication (P<0.001). The sinus venosus occurred in 29 patients, of which 62.07% and 37.93% were medium and large, respectively. PH was observed in nine children, 88.89% were large. ASD closure had significant association with location, and complication (P<0.001). From secundums, surgery and occluder devices closed 40.75% and 15.80, respectively. From those closed by surgery, 8.12% had residuals, 10.26% were partial anomalous pulmonary venous connection (PAPVC) as comorbidities, and 3.42% had pulmonary hypertension.

Conclusion: From the study concluded ASDs size had significant association with closure, location, and complication and ASDs closure had significant association with location and complication.

Key Words: Atrial septal defect, Children, Clinical course.

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Corresponding Author:

Alireza Teimouri, M.Phil., PhD in Demography, Children and Adolescent Health Research Center, Resistant Tuberculosis Institute, School of Medicine, Zahedan University of Medical Sciences, Zahedan 9816743111, Iran.

Email: alirezateimouri260@gmail.com

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1- INTRODUCTION

Atrial septal defects (ASDs) are from a group of CHD that allow a link between the left and right sides of the heart (1). ASDs are the third most common type of CHD, with an estimated incidence of 56 per 100,000 livebirths. With improved recognition of clinically silent defects by echocardiography, recent estimates are about 100 per 100,000 live births. About 65–70% of ASDs are secundum, 50% are primum, and 40–50% are sinusvenosus (1, 2). ASDs account for approximately 13% of CHD (2), and in Iran, it is reported that this rate is 15.8% (3), with a prevalence of 1.6 per 1000 live births (4). For the type of ASDs ratio, there are various percentages such that in another study, primum accounted for 15% and sinus venosus (5–10%) (5). From ASD types, primum and sinus venosus are never amenable to percutaneous device closure and require surgical repair. Primum ASD closure often requires repair of the left-sided AV valve, and sinus venosus ASD closure usually requires intracardiac rerouting of the anomalous right-sided pulmonary veins to the left atrium (2, 6). A study conducted by Tanghöj et al. (7) reported that from 112 ASD patients, 22 (9%) children had complications. From these complicated ASDs 16 (7%) were major and six (2%) were minor. (7). Surgical and device ASD closure in some cases, are sometimes postponed to the age of 4–6 years because of suspected higher procedure related complication rates in smaller children and the chance of spontaneous closure of the defect in early childhood (7). Surgery has been considered the standard treatment of ASDs ever since the late 1960s with good longterm post-operative results and is still followed. In this regard, King and Mills described the first catheter-based closure of secundum ASD in 1976. Transcatheter closure of ASD has gradually become more common and has been associated with less complications and shorter hospitalization. Today, the transcatheter approach is considered safe and effective, with few, but non-negligible, short- and long-term adverse events (5-7). There is a lack of comprehensive study on all-important features of ASDs. In this regard there have been many studies on specific factors such as Behjati-Ardakani et al. (6) that had evaluated the association of age with ASD complication, size and closure by device. Geva et al. (1) conducted a study to find the causes and assess the anatomy, natural history such as changes in size, diagnosis and treatment of ASDs when Nashat et al. (8) directed a study to find PH effects on ASD status as a complication. Considering the above-mentioned reasons, the present study aimed to evaluate clinical course of ASDs and assess the relationship between complication, location, closure and the size in children of the Sistan and Baluchestan province that is located in the East of Iran.

2- MATERIALS AND METHODS

2-1. Type of study

This cross-sectional study was conducted in the cardiac center of the pediatric ward in Ali Asghar hospital, Zahedan University of Medical Sciences, Zahedan, Sistan and Baluchestan province, Iran. The study was carried out on congenital heart defect (CHD) children with diagnosis of ASDs; they comprised 529 out of 3,950 CHD patients. The ASD children were aged up to 18 years and consisted of all those CHD children who referred to the cardiac center for follow-up and checking as outpatients between the years of 2003 and 2018.

2-2. Criteria

ASDs can be presented as an isolated or in association with other congenital heart conditions such as VSD, PDA, PS and more defects. The present study investigated those ASDs that were isolated. Therefore, those patients who is

ASDs were associated with other congenital heart defects were excluded from the study. After ASDs closure by surgery, partial anomalous pulmonary venus connection (PAPVC) was observed in some of the children which was considered as a comorbidity and categorized as ASD complication.

2-3. Study design

After identification the ASD children underwent echocardiography and complete examination such as physical exams, ECG and chest X-ray at every visit during follow-up. Echocardiography was executed using a 2-D echocardiography machine with facility for color Doppler and M-mode. A diagnosis of ASDs was confirmed by a transthoracic echocardiography (TTE). A unique cardiologist applied transthoracic echocardiography to get information about size, location, and the number of the defects as well as hemodynamic information such as pulmonary artery pressure and any associated lesions. Those patients with suspected pulmonary hypertension were under catheterization to measure pulmonary artery pressure.

Required details concerning the patients were biodata, diagnosis, treatment, follow-up and other relevant information recorded prospectively. The pediatric cardiologist followed up the patients and the patient received medical treatment if needed during follow up. Those who required surgical or device for closure were referred to surgery heart department whether inside or outside the province of Sistan and Baluchestan. ASDs were classified based on type of Primum, secundum, Sinus venous and coronary (2). The Primum, Sinus venous and coronary ASDs must be closed by surgery due to not having rim. Device closure has become the first choice for secundum ASD defect closure if it has diameter < 38 mm and rim > 5 mm. ASDs were also classified according to the size. ASDs size are considered small (> 3 mm to 5 mm), medium (> 5 mm to 9 mm), and large (≥10 mm) for infancy and less than 10 mm as small, 10 - 20 mm as medium, and larger than 20 mm as large after infancy (6).

2-4. Ethical Approval

Informed consent was obtained from all participants or their parents after the study approval. The Children and Adolescent Health Research Center and the Ethics Committee of Zahedan University of Medical Sciences, Zahedan, Iran approved the study project (project code: 9581).

2-5. Statistical Analysis

The data were analyzed using SPSS version 20 software (IBM Corp., Armonk, NY, USA). Descriptive statistics for categorized variables were presented as percentages and frequency, and for the analysis, chi-squared test was used with $p < 0.05$ as the level of significance.

3- RESULTS

The present study aimed to investigate clinical course of ASD in children. Among our CHD children, 529 were ASD, of which 278 (52.6%) were girls. Most of the ASDs were medium (46.1%). 44.2% closed by surgery and about 90.9% were secundum, while only 3.6% were primum. From ASDs that were closed by surgery, 3 had brain damage. One of these patients improved after six months, and one expired after two weeks probably due to a comorbidity and the third patient is alive with cerebral palsy. From 11.9% of ASDs that had complication, 6.2% were associated with partial anomalous pulmonary venus connection (PAPVC), 3.8% had residuals, 0.2% had device malposition and 1.7% had pulmonary. About 54.6% (n=289) of patients were less than 12 months old and 32.7% (n=173) were aged 12-60 months at the time of ASD diagnosis. The remained patients were older. Time between ASDs diagnosis and treatment was categorized in <6, 6-12

and 12-24 months with the percentages of 20.4 % and 20.8% and 25.5% respectively. Most of the ASDs had regular follow-up (69.9%) as an outpatient (**Table.1**). **Table.2** showed the sex distribution in various characters of ASDs. The association between sex and ASD size was not significant (Chi-square =0.079, p=0.961), the same trend was observed with closure (Chi-square =4.735, p=0. 192), location (Chi-square =2.219, p=0.232), and complication (Chi-square =3.319, p=0.506). **Table.3** shows the association between size and other characteristics of ASDs. As observed from the table, of the 133 patients whose ASD closed spontaneously, 74.44% and 25.65% were sized small and medium respectively, while no large ASDs were observed. About 234 ASDs were closed by surgery, of which two (0.85%), 96(41.03%), and 136 (58.12%) were small, medium and large size respectively. From those who their ASD closed by occlude devices, 14 (18.18%) were small, 55 (71.43%) were medium and 8(10.39%) were large. In total, 85 ASDs were not closed during the study, of which 66 (77.6%) of them were aged <12 months. The analysis showed a significant association between the ASD size and the closure type (Chi-square =349.865, p<0.001). ASD location had a significant association with the size (Chi-square =22.497, p<0.001), so that from 19 primum, 63.16% were large. From 481 secundum ASD, the majority were medium size (45.53%). The location of sinus-venosus accounted for 29 subjects with 62.07% medium and 37.93%, large. Complication as one of ASD characteristics consisted of residuals (20 subjects) the majority of which (65.00%) were large. Device malposition (one subject had the size of medium), the majority of partial anomalous pulmonary venus connection (PAPVC=33) were of medium size (54.55%). Pulmonary Hypertention (PH) as complication was observed in nine children, from which 88.89% were large.

Table-1: The frequency of ASDs based on categories of the study variables (n=529).

Variables	Groups	Frequency	Percentage
Gender	Boys	251	47.4
	Girls	278	52.6
Size	Small	126	23.8
	Medium	244	46.1
	Large	159	30.1
Closure	Spontanious	133	25.1
	Surgery	234	44.2
	Transcatheter	77	14.6
	Not closed	85	16.1
Location	Primum	19	3.6
	Secundum	481	90.9
	Sinus venosus	29	5.5
Complication	Residuals	20	3.8
	Device malposition	1	.2
	PAPVC	33	6.2
	No complication	466	88.1
	Pulmonary Hypertension	9	1.7
Follow-up	Regular	370	69.9
	Non-regular	159	30.1

Age at diagnosis (Months)	<12	289	54.6
	12-60	173	32.7
	60-132	62	11.7
	>132	5	.9
Age at intervention, (Months)	<12m	289	54.6
	12m-48m	136	25.7
	48m-96m	79	14.9
	>96m	25	4.7
Time between diagnosis and intervention, (Months)	<6m	108	20.4
	6m-12m	110	20.8
	12m-24m	135	25.5
	24m-48m	99	18.7
	>48m	77	14.6
	Total	529	100.0

ASD: atrial septal defect, PAPVC: partial anomalous pulmonary venous connection.

Table-2: Sex distribution on ASDs size, closure, location and complication.

ASD characters	Type	Statistics	Gender		Total	Chi-square	P-value
			Boys	Girls			
Size	Small	n	60	66	126	0.079	0.961
		%	23.9%	23.7%	23.8%		
	Medium	n	117	127	244		
		%	46.6%	45.7%	46.1%		
	Large	n	74	85	159		
		%	29.5%	30.6%	30.1%		
Closure	Spontaneous	n	70	63	133	4.735	0.192
		%	27.9%	22.7%	25.1%		
	Surgery	n	112	122	234		
		%	44.6%	43.9%	44.2%		
	Transcatheter	n	37	40	77		
		%	14.7%	14.4%	14.6%		
	Not closed	n	32	53	85		
		%	12.7%	19.1%	16.1%		
Location	Primum	n	10	9	19	2.219	0.232
		%	4.0%	3.2%	3.6%		
	Secundum	n	223	258	481		
		%	88.8%	92.8%	90.9%		
	Sinus venosus	n	18	11	29		
		%	7.2%	4.0%	5.5%		
Complication	Residuals	n	10	10	20	3.319	0.506
		%	4.0%	3.6%	3.8%		
	Device malposition	n	1	0	1		
		%	.4%	0.0%	.2%		
	PAPVC	n	19	14	33		
		%	7.6%	5.0%	6.2%		
	No complication	n	218	248	466		
		%	86.9%	89.2%	88.1%		
	Pulmonary Hypertension	n	3	6	9		
		%	1.2%	2.2%	1.7%		
	Total	n	251	278	529		
		%	100%	100%	100%		

ASDs: atrial septal defects; PAPVC: partial anomalous pulmonary venous connection.

Table-3: The association of ASDs size with closure, location and complication.

ASD characteristics	Type	Statistics	Size			Total	Chi-square	P- value
			Small	Medium	Large			
Closure	Spontaneous	n	99	34	0	133	349.865	<0.001
		%	74.44%	25.56%	0.00%	100.00%		
	Surgery	n	2	96	136	234		
		%	0.85%	41.03%	58.12%	100.00%		
	Transcatheter	n	14	55	8	77		
		%	18.18%	71.43%	10.39%	100.00%		
	Not closed	n	11	59	15	85		
		%	12.94%	69.41%	17.65%	100.00%		
	Total	n	126	244	159	529		
		%	100.00%	100.00%	100.00%	100.00%		
Location	Primum	n	0	7	12	19	22.497	<0.001
		%	0.00%	36.84%	63.16%	100.00%		
	Secundum	n	126	219	136	481		
		%	26.20%	45.53%	28.27%	100.00%		
	Sinus venous	n	0	18	11	29		
		%	0.00%	62.07%	37.93%	100.00%		
	Total	n	126	244	159	529		
		%	100.00%	100.00%	100.00%	100.00%		
Complication	Residuals	n	0	7	13	20	41.297	<0.001
		%	0.00%	35.00%	65.00%	100.00%		
	Device malposition	n	0	1	0	1		
		%	0.00%	100.00%	0.00%	100.00%		
	PAPVC	n	1	18	14	33		
		%	3.03%	54.55%	42.42%	100.00%		
	No complication	n	125	217	124	466		
		%	26.82%	46.57%	26.61%	100.00%		
	Pulmonary Hypertension	n	0	1	8	9		
		%	0.00%	11.11%	88.89%	100.00%		
	Total	n	126	244	159	529		
		%	100.00%	100.00%	100.00%	100.00%		

ASDs: atrial septal defects; PAPVC: partial anomalous pulmonary venous connection.

Table.4 showed a significant association between closure and location (Chi-square =40.051, p<0.001), and complication (Chi-square =5.491, p<0.001) ASDs. From the table it is shown that all primum ASDs were closed by surgery (19 subjects). From 481 secundum ASDs, 196 (40.75%), and 76 (15.80) were closed by surgery and occlude devices, respectively. 72.41% of 29 sinus venosus ASDs were closed by surgery and the remainder were not closed. From 234 ASDs that were closed by surgery, 19(8.12%) had residuals, 24(10.26%) were with PAPVC as comorbidities, 8 (3.42%) had PH. From 77 ASD that were closed by occluder devices, 1(1.3%) had complication of device malposition and one (1.3%) had PH. **Table.5** showed the significant association between ASD complications and locations (Chi-square =0.574, p<0.001). The table showed that from 19 primum ASDs, 18(94.74%) had residuals and one had no complication. From 481 secundum ASDs, two had residuals, one had device malposition, 17 had PAPVC and eight children had PH. From those who had sinus-venosus (29), 16(55.17%) had PAPVC. The remaining cases had no complications.

Table-4: The association of ASDs closure with location and complication.

ASD characteristics	Groups		Closure				Total	Chi-square	P-value
			Spontaneous	Surgery	Transcatheterr	Not closed			
Location	Primum	n	0	19	0	0	19	40.051	<0.001
		%	0.00%	100.00%	0.00%	0.00%	100.00%		
	Secundum	n	132	196	76	77	481		
		%	27.44%	40.75%	15.80%	16.01%	100.00%		
	Sinus venosus	n	0	21	0	8	29		
		%	0.00%	72.41%	0.00%	27.59%	100.00%		
Complication	Residuals	n	0	19	0	1	20	5.491	<0.001
		%	0.00%	8.12%	0.00%	1.18%	3.78%		
	Device malposition	n	0	0	1	0	1		
		%	0.00%	0.00%	1.30%	0.00%	0.19%		
	PAPVC	n	0	24	0	9	33		
		%	0.00%	10.26%	0.00%	10.59%	6.24%		
	No complication	n	133	183	75	75	466		
		%	100.00%	78.21%	97.40%	88.24%	88.09%		
	Pulmonary Hypertension	n	0	8	1	0	9		
		%	0.00%	3.42%	1.30%	0.00%	1.70%		
	Total	n	133	234	77	85	529		
		%	100.00%	100.00%	100.00%	100.00%	100.00%		

ASD: atrial septal defect; PAPVC: partial anomalous pulmonary venus connection.

Table-5: The association between ASDs complication and location.

Location		Complication					Total	Chi-square	P-value
		Residuals	Device malposition	PAPVC	No complication	Pulmonary Hypertension			
Primum	n	18	0	0	1	0	19	0.574	<0.001
	%	94.74%	0.00%	0.00%	5.26%	0.00%	100.00%		
Secundum	n	2	1	17	453	8	481		
	%	0.42%	0.21%	3.53%	94.18%	1.66%	100.00%		
Sinus venosus	n	0	0	16	12	1	29		
	%	0.00%	0.00%	55.17%	41.38%	3.45%	100.00%		
Total	n	20	1	33	466	9	529		
	%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%		

ASD: atrial septal defect, PAPVC: partial anomalous pulmonary venous connection.

4- DISCUSSION

ASDs are the third most common type of CHD, with an incidence of 56/100,000 that improved to 100/100,000 live births with recognition of clinically silent defects by echocardiography (1). ASDs were prevalent in 9.8% CHD such that of these, 60.4% are females (3). In this regard, the present study found 13.4% that shows a higher rate regardless of all differences with the Behjati-Ardakani et al. study (6). From the present study higher sex-ratio in ASD patients was observed similar to Nashat et al. (8), Behjati-Ardakani et al. (6), and Mohammad Refaei et al.'s studies (9), that showed the majority of ASD patients were girls, but Amel-Shahbaz et al. (3) found the opposite trend. Age as a key factor in ASD patients, influenced the high incidence of PH. McMahon et al. (10) showed that PH rate was higher compared to the present study, which may be due to delays in diagnosis or referral which could be a reason for the higher age of the patients. McMahon et al.

(10) also showed that spontaneous closure occurred only during infancy and childhood. However, in adolescence and adulthood, no spontaneous closure was observed. Therefore, ASD in adolescents and adults should be followed up to determine if surgical repair is necessary or whether transcatheter occluder can be used. McMahon et al. (10) showed that ASD size decrease occurred in 12.7% of infants and children with an ASD size of less than 9 mm. The present study resulted that the most common ASD was medium (46.1%) such that most of them were closed by surgery (44.2%). About 90.9% were secumdum and a low percentage was primum (3.6%). 11.9% of our ASDs had complications that were PAPVC (6.2%), residual (3.8%), device malposition (0.2%), and PH (1.7%). The present study revealed that residuals were the most common complication compared with device malposition and PH and most of the ASDs had regular follow-up.

In this regard, Behjati-Ardakani et al. (6) resulted that the size of the ASDs was medium with the highest percent (52.6%). The authors also found that 93.2% of ASDs were simple secundum, 2.6% were primum, 1.6% were sinus venous, and 2.6% were a combination of different ASD types. In this study, the most common complication was PH that was found most frequently in adults (22 individuals) and least frequently in children (5 individuals). In addition, the authors concluded that small ASD occurred in infants, medium ASD in children, and large ASD in adults and spontaneous closure occurred in infancy and childhood. Comparing to the present study, PH was more frequent in Behjati-Ardakani et al's results. This is probably due to this fact that Behjati-Ardakani et al.'s study was conducted on 192 ASD patients consisted of 22 infants, 81 children, 25 adolescents, and 64 adults when the present study was consisted of 54.6% infants and the overall patients were younger than 19 years old. Refaei et al. (9) conducted a study on 141 patients with ASD and resulted that ASDs size was associated with closure, location and complication. From those ASDs closed spontaneously, the majority were small and then followed by medium. In the present study, the ASDs that closed spontaneouly were 25.1% of 529, about 44.2% of ASDs were closed by surgery and occluder devices closed 14.6%. From those whose location was secundum, most of them were medium sized (45.53%), and then followed by large (28.27%), and small (26.20%). From those ASDs that were sinus-venosus, most of them were medium (62.07%), and then large (37.93%). Not small size ASDs were observed in this location. The present study also revealed that from those whose complication was residual (20 patients), the majority were large (13 patients).

A 15-month-old girl had device malposition, the size was medium and she was referred to cardiac center for removing the device and closing her ASD by surgery. Of the ASDs that had PH, most of them were large and only one ASD was medium. Mohammad Refaei et al. (11) resulted that ASD size enlarged with increase in age. In Mohammad Refaei et al.'s study (11), the distribution of spontaneous closure based on the ASD size was 69.1%, 35.6% and 7.1% in small, moderate and large. ASDs greater than 8 mm are unlikely to close, although perhaps in rare condition it would be closed. Fiszer et al., reported a 6-month-old girl as a case with a large secundum ASD sized 11 mm that closed spontaneously within 1 year. The authors also reported that the ASD size might become larger while waiting for a suitable time for intervention, the range of enlargement defects was reported to vary from 29% to 65%. For example, a case with a small ASD (size 3–4 mm) enlarged to 24 mm after 6 years, and another case, an infant with a defect

size that enlarged from 9 mm to 27 mm over a period of 9 years, from these cases it is observed that interventional treatment is unsuitable in both cases and they would be closed by surgery. For more information about this result, Saito et al. (12) had no spontaneous closure in medium in pediatric patients. Generally it is believed that large defects usually do not close with age but become larger as the patients grow. In contrast, small ASDs close spontaneously while growing. In this regard, the highest number of spontaneous closures occurred in patients younger than 2 years. This finding did not support the role of age in closure because size played the main role in spontaneous closure. In the present study, from 133 ASDs that closed spontaneously, 88.7% and 10.5% were aged <12 months and 12-48 months respectively. This occurrence was observed in the age of 48-96 months in a small size. Spontaneous closure of medium and large ASDs did not occur, and the defect was recognized in older ages (6).

However, the present study observed 34 medium sized ASDs that closed spontaneously in infancy. It mustbe noted that our patients with medium size were <10mm. The median and the maximum age of Behjati-Ardakani patients were 2.25 and 3.9 years, andtheir defect closed spontaneously; this is in line with Hanslik et al. (13) that indicated spontaneous closure can occur beyond infancy. Therefore, the window of opportunity for selective surgery can be determined according to patient age. None of the patients with small ASD size needed surgery. In our study, 72.4% of patients needed surgery or transcatheter closure, a finding that is similar to the results of Hanslik et al.'s study (13). In Behjati-Ardakani et al.'s study (6), a very low percentage of inpatients had supraventricular arrhythmias during the transcatheter, when the present study did not find this complication in the outpatients. Rossi et al. (14) found that almost all ASDs with residual were closed by surgery. In one of their patients, malposition device was observed three months after intervention. They reported that the majority of ASDs with PH were closed by surgery. The authors concluded that, after early closure by surgery or by transcatheter device implantation, a good improvement in right ventricular and right atrial volume overload can be achieved. In this regard, Rastegari et al. (15) reported no complications, and successful closure was achieved in all their patients. Vogel et al. (16) studied 12 consecutive symptomatic inpatient children aged 2 years consisted of six with failure to thrive, 5 with chest infections, and 1 with heart failure. They reported that from their inpatients, ten underwent successful closure and two-needed surgery because of device malposition.

In the present study, as mentioned, a girl aged 15 months had the same condition and referred to the cardiac center to remove the device and ASD closure by surgery. Butera et al. (17) demonstrated that safety and efficacy of ASD percutaneous closure in children had some clinical effects. The first important advantage of percutaneous transcatheter is related to their lesser psychological effects. In fact, the absence of skin scars, the shorter hospitalization, reducing the incidence of arrhythmias are the main reasons given for the satisfaction of patients or their parents. In this regard, from our outpatients about 14.6% of ASDs were closed by percutaneous transcatheter. In Behjati-Ardakani et al.'s study (6), 93 (48.4%) cases were closed by transcatheter and 46 (24%) by surgery. In the transcatheter group, 8.2% of patients experienced complications, and 10.4% of patients from the surgical group suffered complications. In the present study, these percentages were 14.6 and 44.2%, respectively such that from those who

were closed by transcatheter, 2.6% had complication when this rate for surgery was 11.5%. Comparing these rates with Behjati-Ardakani's study rates shows semi-similarity in surgery and a considerable gap in transcatheter closure (6). Farooqi et al. (18) reported that the number of surgical closures increased significantly in sinus-venosus ASD. From the present study it can be resulted that of 29 sinus venosus ASDs, 21(72.41%) were closed by surgery. Sinus venosus ASDs are closed by surgery when associated with PAPVC. Moore et al. (19) found that mean ASD size was smaller in infants than children and neonates. While in the present study the ASD size increased by age such that mean sizes of ASD were 7.07±2.67, 8.4 ±3.8, and 13.76±5.47 for neonate, infant and children, respectively.

The difference that was observed comparing with the present study would probably be due to the low number of neoates in the study of Moore et al. (19) that were lower than our study. They also reported that ASD device occluder was implanted in 95.7% of patients. The present study found 77(14.6%) patients whose ASD was closed by occluder device that is lower than Moore et al.'s study, which is due to population differences in the two studies. Werner et al. (20) reported a case of device fracture in a young asymptomatic woman almost 4 years after percutaneous secundum ASD closure, resulting in mitral valve perforation. Subsequently, for the patient, elective surgical removal of the device and mitral valve reconstruction was performed. Similar to the present study that found a device malposition in a 15-month-old girl. This case demonstrated that complications due to transcatheter ASD closure may even occur later, after implantation. Kodaira et al. (21) conducted a study on comparing percutaneous transcatheter closure and minimally invasive cardiac surgery (MICS) in ASD patients and resulted that both methods had high success rates without deaths. Their study confirmed the dominance of percutaneous closure of secundum ASD with anatomically suitable features. In this regard, several studies such as Butera et al.'s study (17) have compared standard surgical with percutaneous closure, and reported lower rates complications and shorter hospital stay with percutaneous closure. The difference in the occurrence of complications between the percutaneous closure and MICS groups could be attributed to the higher incidence of atrial arrhythmia in the MICS group.

5- CONCLUSION

Based on the results, most of the ASDs were medium. Near half were closed by surgery and about nine tenths were secundum and then sinus venosus. A significant association was observed between size and the closure type and location. About 11.9% of ASDs had complication. A quarter closed spontaneously, half by surgery and near 15% by device occluder. Most of the primum ASDs were large and most of the secundum were medium From sinus-venosus ASDs, 62.07% and 37.93% were medium and large respectively. Majority of PHs were large. ASD closure had a significant association with location and complication. All primum were closed by surgery and from secundums, nearly half were closed by surgery. From those closed by occluder device, 1 had complication of device malposition and 1had PH. ASDs that were closed by device occluder had lower rate of residuals and PH compared to those by surgery. Routine clinical follow-up with serial echocardiography may be the best way to identify the type of ASD closure that will close spontaneously or by surgery or transcatheter in future regardless of the age. More surveillance on ASDs closed by surgery than spontaneously by cardiac experts is recommended.

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