ORIGINAL ARTICLE

Arrhythmia during diagnostic cardiac catheterization in pediatric patients with congenital heart disease

Doğumsal kalp hastalığı olan pediatrik hastalarda kalp kateterizasyonu sırasında gelişen ritim bozuklukları

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ABSTRACT

Objective: Diagnostic and interventional cardiac catheterization procedures for congenital heart diseases (CHD) are becoming increasingly more popular, and arrhythmia is a well-known complication. This study was an evaluation of the incidence and causative agents of arrhythmia and the subsequent treatment strategies applied during cardiac catheterization.

Methods: The catheterization data of all of the patients who underwent diagnostic cardiac catheterization for CHD between January 2012 and 2018 at a single center were examined retrospectively.

Results: A total of 1316 children underwent diagnostic cardiac catheterization due to CHD. The median age and body weight was 18 months (6 days-21 years) and 9.9 kg (2.2–135 kg), respectively. Patients with ventricular septal defect (281 patients) and those with tetralogy of Fallot (257 patients) represented 2 major groups of the study population. In 93 (7%) patients, arrhythmia developed during cardiac catheterization. Among them, there were 58 (62%) cases of bradyarrhythmia and 35 (38%) cases of tachyarrhythmia. Arrhythmia was classified as low, high, or major, according to the adverse event severity score; the rates were 2.7%, 4.3%, and 1.2%, respectively. In 36 (39%) patients, there was no need for therapy, whereas 57 (61%) required treatment to eliminate the arrhythmia. Treatment modalities included catheter manipulation in 15, pharmacological therapy in 24, and cardioversion in 3 patients. Eleven patients required cardiopulmonary resuscitation. Temporary pacemaker implantation was required in 2 patients, while 2 others underwent permanent pacemaker implantation secondary to catheterization-related arrhythmia. There were no cases of mortality secondary to catheterization-related arrhythmia.

Conclusion: Diagnostic cardiac catheterization in CHD may result in various types of cardiac arrhythmias. The proper management of arrhythmias may reduce morbidity and mortality related to cardiac catheterization.

ÖZET

Amaç: Doğumsal kalp hastalıklarının (DKH) tanısı ve tedavisi sırasında kalp kateterizasyonu kullanımı gün geçtikçe artmaktadır. Aritmi kateterizasyon sırasında görülebilen bir komplikasyondur. Bu çalışmada kalp kateterizasyonu sırasında gelişen aritmik olayların sıklığı ve tedavisinin değerlendirilmesi amaçlanmıştır.

Yöntemler: Ocak 2012–2018 tarihleri arasında DKH nedeni ile tek bir merkezde kalp kateterizasyonu yapılan hastaların bilgileri geriye dönük olarak değerlendirildi.

Bulgular: Toplam 1316 hastaya DKH nedeni ile tanısal amaçlı kalp kateterizasyonu yapıldı. Hastaların ortalama yaşı ve ağırlığı sırasıyla 18 ay (6 gün–21 yıl) ve 9.9 kg (2.2–135 kg) idi. Ventriküler septal defekt (281 olgu) ve Fallot tetrolojisi (257 olgu) iki grupta en sık görülen DKH idi. Doksan üç (%7) olguda kardiyak kataterizasyon sırasında aritmi gözlendi. Elli sekiz (%62) olguda bradiaritmi ve 35 (%38) olguda taşiaritmi saptandı. Görülen aritmiler, yan etki ciddiyet sınıflandırma sistemine göre; düşük, yüksek, majör olarak sınıflandırıldı ve sıklıkları sırası ile %2,7, %4.3 ve %1.2 olarak saptandı. Olguların 36'sında (%39) tedavi gerekmedi, 57 olguda (%61) ise aritmiyi gidermek için tedavi gerekti. Tedavi yaklaşımları; 15 olguda kateter manipülasyonu, 24 olguda tıbbi tedavi ve üç olguda kardiyoversiyon idi. Hastaların 11'inde kardiyopulmoner canlandırma yapılması gerekti. İki olguda geçici kalp pili takılması gerekir iken, iki olguda kateterizasyona bağlı aritmi nedeniyle kalıcı kalp pili ihtiyacı oldu. Kateterizasyona bağlı aritmi nedeniyle kaybedilen olgu olmadı.

Sonuç: Doğumsal kalp hastalıkları olan olgularda tanısal kalp kateterizasyonu sırasında her tür aritmi ile karşılaşılabilir. Bu aritmilerin uygun bir şekilde tedavi edilmesi mortalite ve morbiditeyi düşürecektir.

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Congenital heart disease (CHD) is quite a heterogeneous and complex group of cardiac malformations. Echocardiography, computed tomography angiography, and other imaging systems have an essential place during a CHD evaluation. Cardiac catheterization and angiographic evaluation are better choices if the lesion or underlying condition remains undetermined using conventional methods or if percutaneous intervention is planned.[1,2]

Advances in the manufacture of catheters and devices, increased operator experience, and high patient volume have resulted in a significant increase in the use and reliability of cardiac catheterization in recent years. Nonetheless, the complication rate after diagnostic catheterization remains at 4.1% to 19%.[3–5] One of the major complications of cardiac catheterization is cardiac arrhythmias; however, there are a limited number of studies in the literature on arrhythmia frequency, type, and management during cardiac catheterization.[6]

In this study, an evaluation of the frequency, type, and causative agents of cardiac arrhythmias, as well as the subsequent treatment strategies applied during catheterization in patients with CHD were assessed.

METHODS

The data of cardiac catheterization performed for CHD patients between January 2012 and 2018 were retrospectively evaluated. The study was approved by our local ethics committee. All of the data were retrospectively obtained from a pediatric cardiology department angiographic database. Interventional cardiac catheterizations and hybrid cases performed in an operating room were excluded. Patients with previously implanted cardiac pacemakers and those whose pre-catheterization 12-lead electrocardiography (ECG) demonstrated any kind of arrhythmia were also excluded from the study. Rhythm disturbances that occurred either during anesthesia induction or recovery (bradycardia, tachycardia) and arrhythmias related with other causes, such as hypoxia or acidosis, were excluded. The preferred anesthesia protocol was either spontaneous breathing or ventilation with a laryngeal mask in room air under deep sedation. The method of ventilation was determined by the anesthesia staff. The anesthetic agents employed were inhaled sevoflurane, and intravenous ketamine and propofol.

A descriptive table including patient age, weight, sex, echocardiographic diagnosis, sedation/anesthesia procedure during catheterization, catheter type, fluoroscopy time, procedure time, presence and type of arrhythmia, hemodynamic effect of arrhythmia, and the management strategy was created. In addition to the angiographic details of all of the patients' ECG recordings, invasive and non-invasive hemodynamic measurements taken until discharge were reviewed.

Abbreviations:

AF	*Atrial fibrillation*
AVB	*Atrioventricular block*
cAVSD	*Complete atrioventricular septal defect*
ccTGA	*Congenitally corrected transposition of the great arteries*
CHD	*Congenital heart disease*
CPR	*Cardiopulmonary resuscitation*
CV	*Cardioversion*
DILV	*Double inlet left ventricle*
DORV	*Double outlet right ventricle*
EAR	*Ectopic atrial rhythm*
ECG	*Electrocardiography*
ECMO	*Extracorporeal membrane oxygenation*
ISNPCHD	*International Society for Nomenclature of Paediatric and Congenital Heart Disease*
LA	*Left atrium*
LAI	*Left atrial isomerism*
PA	*Pulmonary atresia*
RAI	*Right atrial isomerism*
RV	*Right ventricle*
SVT	*Supraventricular tachycardia*
TAPVC	*Total anomalous pulmonary venous connection*
TOF	*Tetralogy of Fallot*
VAC	*Ventriculoarterial concordance*
VAD	*Ventriculoarterial discordance*
VF	*Ventricular fibrillation*
VSD	*Ventricular septal defect*
VT	*Ventricular tachycardia*

The arrhythmias were classified as asystole, sinus bradycardia, nodal rhythm, conduction abnormalities (first degree, 2:1, or complete atrioventricular block [AVB]), supraventricular arrhythmias (supraventricular tachycardia [SVT], ectopic atrial rhythm [EAR], premature atrial beats, atrial fibrillation [AF], atrial flutter, or focal atrial tachycardia), and ventricular arrhythmias (ventricular extrasystole, ventricular tachycardia [VT], or ventricular fibrillation [VF]).

The International Society for Nomenclature of Paediatric and Congenital Heart Disease (ISNPCHD) proposed a new nomenclature system for procedures for and complications of cardiac catheterization in children.[1,7,8] Complications were evaluated using 5 grades according to severity:

Level 1: None: No harm, no change in condition, may have required monitoring to assess for potential change in condition with no intervention indicated.

Level 2: Minor: Transient change in condition, not life-threatening; condition returned to baseline, re-

quired monitoring, required minor intervention, such as withholding a medication or obtaining a lab test.

Level 3: Moderate: Transient change in condition, may be life-threatening if not treated, condition returned to baseline, required monitoring, required intervention such as a reversal agent, additional medication, transfer to the intensive care unit for monitoring, or moderate transcatheter intervention to correct the condition.

Level 4: Major: Change in condition, life-threatening if not treated, change in condition may be permanent, may have required an intensive care unit admission or emergent readmission to hospital, may have required invasive monitoring, required interventions such as electrical cardioversion or unanticipated intubation, or required major invasive procedures or transcatheter interventions to correct the condition.

Level 5: Catastrophic: Any death, emergent surgery, or heart-lung bypass support (extracorporeal membrane oxygenation [ECMO]) to prevent death with failure to wean from bypass support.

Levels 1 and 2 were classified as low adverse event severity, whereas Levels 3, 4, and 5 were classified as high adverse event severity. Level 4 was defined as major adverse event severity.[1,7,8]

The management of arrhythmia during cardiac catheterization was classified as:

1. Spontaneously resolved without any intervention (transient)
2. Resolved with catheter manipulation
3. Cardioversion (CV)
4. Pharmacological treatment
5. Cardiopulmonary resuscitation (CPR)
6. Temporary pacemaker
7. Permanent pacemaker

Clinical arrhythmia management

The first technique to be applied when arrhythmia developed during cardiac catheterization was to determine the type and hemodynamic significance of the arrhythmia. Most of the time, arrhythmias resolve spontaneously and do not require treatment. If the arrhythmia is clinically important, the first treatment modality used is catheter manipulation. In cases where an arrhythmia could not resolved by catheter manipulation, the treatment was managed in accordance with the American Heart Association Guidelines.[9]

Statistical analysis

SPSS for Windows, Version 15.0 (SPSS Inc., Chicago, IL, USA) was used to perform the statistical analyses. Continuous variables were expressed as median (range) and categorical variables were expressed as percentages. The Mann-Whitney U test was used to compare the mean values of the 2 groups, while a chi-square and Fisher's exact test were used to compare the findings between groups. P values <0.05 were considered statistically significant.

RESULTS

Patient characteristics

A total of 2693 cardiac catheterizations were performed during the study period. Of those, 1316 (48.8%) with complete diagnostic catheterization data available were included in the study. Among all of the catheterizations, 54% (n=708) were performed in males; the median catheterization age was 18 months (range: 6 days–21 years), and the median body weight was 9.9 kg (range: 2.2–135 kg).

The patients' demographic characteristics are shown in Table 1.

Echocardiographic diagnosis and arrhythmia types

The major diagnoses of the patients were ventricular septal defect (VSD; 281 patients), tetralogy of Fallot (TOF; 257 patients), VSD-pulmonary atresia (114 patients), right or left atrial isomerism (87 patients), double outlet right ventricle (DORV; 49 patients), and congenitally corrected transposition of the great arteries (ccTGA; 41 patients). A total of 837 patients (64%) had biventricular physiology, while 479 (36%) patients had univentricular physiology.

Among 87 patients with heterotaxy syndrome, 58 (67%) were right atrial isomerism (RAI) and remaining 29 (33%) patients had left atrial isomerism (LAI). In the RAI group, 34 patients had complete atrioventricular septal defect (cAVSD), DORV, and pulmonary stenosis; 21 patients had cAVSD, DORV, and pulmonary atresia (PA); and 3 patients had VSD and pulmonary hypertension. Thirteen RAI patients also had total anomalous pulmonary venous connection

Table 1. Data of the patients and catheterization procedures

Characteristics	Total n=1316	Non-arrhythmia n=1223 (93%)	Arrhythmia n=93 (7%)	*p*
Age, median (range)	18 months (6 days–21 years)	17 months (6 days–21 years)	15.5 months (9 days–17 years)	>0.05
Body weight, kg, median (range)	9.9 (2.2–135)	11 (2.2–135)	8.5 (3–72)	>0.05
Height, cm, median (range)	47–184 (80)	47–184	50–174 (73)	>0.05
Gender, n (%)				
Male	708 (54)	659 (53)	49 (52)	>0.05
Famale	608 (46)	564 (47)	44 (48)	
Procedure time, min, median (range)	37.5 (10–130)	40 (10–130)	30 (10–240)	>0.05

(TAPVC). In the LAI group, 14 patients had cAVSD, DORV, and PS; 4 patients had DORV, VSD, and PS; another 3 patients had mitral atresia; 2 had cAVSD and PA; and various other pathologies were seen in 6 patients. TAPVC was observed in 2 of the LAI patients.

In all, 140 (11%) patients had cardiac surgery before cardiac catheterization. The earlier operations were a Glenn shunt (n=80), Kawashima (n=6), or Fontan procedure (n=5) for single ventricle patients, whereas a transannular patch or conduit repair was selected in TOF (n=26) and VSD-pulmonary atresia (n=8) patients, and in 15 patients, other surgical procedures were performed.

Cardiac arrhythmia developed in 7% (n=93) of these diagnostic catheterizations. Of these arrhythmias, 58 (62%) were bradyarrhythmia and 35 (38%) were tachyarrhythmia. Among the cases of bradyarrhythmia, the most common was an AV conduction abnormality, seen in 44 (47%) of 93 patients. The most common tachyarrhythmia was supraventricular arrhythmia, observed in 26 (28%) of 93 patients. When the arrhythmias were classified according to the diagnosis, they were most commonly associated with an Ebstein anomaly (37% of all Ebstein anomaly patients), ccTGA (24% of all ccTGA patients), and double inlet left ventricle (DILV, 19% of all DILV patients). Patient diagnoses and arrhythmia types are provided in Table 2.

The incidence of complete AVB was remarkably high in patients with TOF. A total of 13 patients developed complete AVB. This complication was seen particularly in patients in whom only a venous catheterization was performed and the catheter was passed through the VSD to the aorta.

Arrhythmia developed in all cases where catheterization was performed solely from the venous side. AV block occurred in 2 cases after entering the ventricle using a catheter, in 1 patient after entering the pulmonary artery, and in another patient after passing through the VSD and entering the aorta. The arrhythmia improved with withdrawal of the catheter and did not recur. Only the patient in whom the VSD was accessed to reach the aorta needed medication for recovery. All of the patients in this group had different degrees of pulmonary stenosis in various segments. None of them had severe pulmonary hypertension

Three (37%) of 8 Ebstein anomaly patients experienced arrhythmia during cardiac catheterization. Neither Ebstein grade nor tricuspid valve regurgitation was correlated with arrhythmia development. None of the Ebstein anomaly patients developed permanent arrhythmia after the cardiac catheterization.

A total of 41 patients with ccTGA underwent diagnostic cardiac catheterization. Ten (24%) of the 41 patients experienced arrhythmia during the procedure. There were 6 cases of complete AVB, 2 of SVT, 1 of AF, and 1 of bradycardia. In 7 (70%) patients, arrhythmia developed during advancement of the catheter to the aorta via the VSD; 6 of them had complete AVB. In the remaining 3 patients, the ventricle injection alone triggered the arrhythmia. In 14 of 41 ccTGA patients, advancement of the catheter to the aorta was attempted from the inferior vena cava; arrhythmias were observed in half of these patients.

Fifty-one patients with DILV underwent diagnostic catheterization: 39 had ventriculoarterial discordance (VAD), 6 had DILV-DORV, 5 had DILV-double outlet left ventricle (DOLV), and 1 had ventriculoar-

Table 2. Arrhythmia frequency and type according to the underlying cardiac disease of the patients

	VSD	TOF	VSD–PA	Isomerism	TA	DILV	DORV	cc–TGA	TGA	HLHS	MA	Arcus hypoplasia	AS	Truncus arteriosus	Ebstein anomaly	Other	Total
	(n=281)	(n=257)	(n=114)	(n=87)	(n=67)	(n=51)	(n=49)	(n=41)	(n=30)		(n=23)	(n=17)	(n=15)	(n=15)	(n=13)	(n=8)	(n=248)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Complete AV block	4 (1.4)	13 (5)	4 (3.5)	1 (1)	1 (1.5)	3 (6)	3 (6)	6 (14)	1 (3)		1 (6)	–	–	–	–	–	37
Supraventricular tachycardia	3 (1)	2 (0.7)	–	5 (6)	–	2 (4)	1 (2)	2 (5)	–		–	1 (0.6)	1 (0.6)	2 (15)	1 (12)	–	20
2:1 AV blok	–	3 (1)	–	–	–	1 (2)	2 (4)	–	–		–	–	–	–	–	–	6
Ventricular tachycardia	–		–	1 (1)	1 (1.5)	1 (2)	–	–	–		–	–	–	–	2 (25)	1 (0.4)	6
Atrial fibrillation/flutter	–	1 (0.3)	1 (1)	–	–	–	–	1 (2)	–		–	–	–	–	–	3 (1)	6
Bradycardia	1 (2)	–	–	–	1 (1.5)	–	–	1 (2)	–		–	–	–	–	–	1 (0.4)	4
Asystole	–	1 (0.3)	–	1 (1)	–	2 (4)	–	–	1 (3)	1 (4)	–	1 (0.6)	1 (0.6)	–	–		8
Ventricular fibrillation	1 (2)	–	–	–	–	–	–	–	–		–	–	–	–	–	–	1
Junctional rhythm	–	–	–	–	–	1 (2)	–	–	–		1 (6)	–	–	–	–	–	2
Frequent ventricular extrasystole	–	–	–	–	–	–	–	–	1 (3)		–	–	–	–	–	–	1
1st degree AV block	–	1 (0.3)	–	–	–	–	–	–	–		–	–	–	–	–	–	1
Branch block	–	–	–	–	1 (1.5)	–	–	–	–		–	–	–	–	–	–	1
Arrhythmia during catheterization	9 (3)	21 (8)	5 (4)	8 (9)	4 (6)	10 (19)	6 (12)	10 (24)	3 (10)	1 (4)	2 (11)	2 (13)	2 (13)	2 (15)	3 (37)	5 (2)	93 (100)

AS: Aortic stenosis; AV: Atrioventricular; ccTGA: Congenital corrected transposition of great artery; DILV: Double inlet left ventricle; DORV: Double outlet right ventricle; HLHS: Hypoplastic left heart syndrome; MA: Mitral atresia; PA: Pulmonary atresia; TA: Tricuspid atresia; TGA: Transposition of great artery; TOF: Tetralogy of Fallot; VSD: Ventricle septal defect.

terial concordance (VAC). Rhythm problems emerged in 10 (20%) of 51 patients. Only 1 of these patients had DILV-DORV, while the remaining 9 patients had DILV-VAD. The catheters were advanced to the aorta through the VSD in all but 1 patient. During the catheterization of 26 patients, the catheters were advanced through the VSD, and arrhythmia occurred in 9 (35%) cases. Of the other 25 patients in whom the catheters were not advanced through the VSD, arrhythmia occurred and a rhythm problem developed in only 1 (4%).

Among all of the patients with arrhythmias, 39% had Level 2, 44% had Level 3, and 17% had Level 4 complications according to the ISNPCHD International Paediatric and Congenital Cardiac Code for severity level. No patients had Level 1 or 5 complications. Among all of the patients, 36 (2.7%) had Level 2 complications, 41 (3.1%) had Level 3 complications, and 16 (1.2%) had Level 4 complications. A low adverse event severity score was assigned in 2.7%, a high adverse event severity score was assigned in 4.3%, and a major adverse event severity score was assigned in 1.2%.

Arrhythmia management

In 36 (39%) of 93 patients, the arrhythmia resolved spontaneously without intervention. Fifty-seven (61%) patients required an intervention to end the arrhythmia during the catheterization procedure. In 15 (16%) of 93 patients, the arrhythmia was resolved after catheter manipulations. Most of these patients (n=9) had supraventricular arrhythmia. Electrical cardioversion was applied in 3 of 93 (3%) patients. Pharmacological treatment (epinephrine, atropine sulfate, adenosine, esmolol, lidocaine) was applied in 24 (26%) of 93 patients. Eleven patients required CPR (1 with complete AVB, 8 with asystole, 1 with AF, and 1 with VF) during the arrhythmia.

In 2 patients (1 with TOF, 1 with ccTGA), a temporary transvenous pacemaker was implanted during the catheterization. In the patient with TOF, the overdrive pacing terminated the arrhythmia immediately. The patient with ccTGA was transferred to the cardiac intensive care unit after catheterization and the complete AVB resolved the following day.

Table 3. Arrhythmia type and treatment modalities

			Management					
			Transient	Mechanical (with catheter)	Electrical cardioversion	Pharmacological	Temporary pacemaker	Permanent pacemaker	CPR
Bradyarrhythmia (n=58, 62%)	AV conduction (n=44, 47%)	Complete AV block	18	4		11	2	1	1
		2:1 AV block	3	2				1	
		1st degree AV block	1						
	Sinus bradycardia (n=4, 4%)		1			3			
	Asystole (n=8, 9%)								8
	Junctional bradycardia (n=2, 2%)		2						
Tachyarrhythmias (n=35, 38%)	Supraventricular arrhythmia (n=26, 28%)	Supraventricular tachycardia	4	8		8			
	Ventricular arrhythmia (n=9, 9.6%)	Atrial fibrillation/flutter	1	1	2	1			1
		Ventricular tachycardia	4		1	1			
		Ventricular fibrillation							1
		Ventricular extrasystole	2						
Total			36 (39%)	15 (16%)	3 (3%)	24 (26%)	2 (2%)	2 (2%)	11 (12%)

AV: Atrioventricular; CPR: Cardiopulmonary resuscitation.

Two of the patients required permanent pacemaker implantation during follow-up in the ward. One had ccTGA and the other had DILV-VAD. No patients required ECMO. There were no cases of mortality secondary to catheter-related arrhythmia. The arrhythmia classification and management strategies are summarized in Table 3.

DISCUSSION

The number of studies about arrhythmias during cardiac catheterization in CHD currently available in the literature is limited. This study was conducted in a high-volume pediatric cardiac center, involved all diagnostic cardiac catheterizations in CHD patients, and evaluated the incidence, classification, and management of arrhythmias.

The results of the study can be summarized as follows:

I. Arrhythmia occurred in 7% of patients during the diagnostic cardiac catheterization.

II. Patients with Ebstein anomaly, ccTGA, and DILV were the most vulnerable to the development of arrhythmia.

III. Age and body weight had no effect on arrhythmia incidence. This finding was also seen in pathologies with a high arrhythmia incidence, such as Ebstein anomaly, ccTGA, and DILV.

IV. The incidence of complete AVB was greatest among ccTGA patients. Complete AVB after catheterization may become permanent over time in ccTGA and DILV-VAD patients.

V. The risk of developing a major complication due to arrhythmias (according to ISNPCHD classification) was 1.2%.

VI. Most arrhythmias during cardiac catheterization resolve spontaneously. Some require catheter manipulation or medication and electrical cardioversion/defibrillation.

The indications for cardiac catheterization are currently limited since echocardiography and magnetic resonance imaging better delineate the anatomy, ventricular function, and severity of atrioventricular valvular regurgitation. The need to assess pulmonary vascular resistance or perform an angiographic evaluation of the coronary arteries or aortic arch, complex

pulmonary atresia, or pulmonary venous abnormalities are potential indications for an invasive study.[2,10,11] The indications for cardiac catheterization in this study were consistent with those in the literature.

In patients with VA discordance, catheterization can be technically difficult due to the morphological relationships of the left ventricle and the pulmonary trunk. If the patient has a VSD, then a catheter can be advanced to the pulmonary artery from the inferior vena cava, through the right atrium and RV, and through the VSD into the morphologically left ventricle and pulmonary artery. The second option is the inferior vena cava, right atrium, atrial septal defect/patent foramen ovale, LA, and through the mitral valve into the morphologically left ventricle and pulmonary artery. Retrograde catheterization from the aorta to the pulmonary artery (if the patient has a VSD) is also possible. The plane of the mitral valve is oblique, rather than vertical, making the pass of the catheter from the right atrium to the pulmonary trunk more difficult than in patients with concordant AV connections. In addition, the AV conduction axis is more vulnerable due to its anterosuperior location, presenting the possibility for traumatic injury with the catheter passage, and thus creating a transient AVB.[10,12] Moreover, in patients with DILV-VAD, L-looping of the ventricles and associated abnormal conduction system, technical difficulty in catheter manipulation, and increased catheter tension due to the anatomy increase the vulnerability of patients to the development of arrhythmias.

In some patient groups, disease-specific situations might increase the arrhythmia risk. In patients with an Ebstein anomaly, right atrium dilatation and difficulty passing the catheter through the tricuspid valve to the RV is common. Also, in patients with TOF or pulmonary atresia with VSD, if a venous approach used for catheterization, it may damage the AV node while advancing catheters to the aorta from the venous side by passing through the VSD due to the localization of the AV node.

Mah et al.[5] reported complete AVB development in 6 patients after catheterization. In 3 cases, complete AVB progressed to permanent blockage. Among the 6, 3 patients had L-looped ventricle anatomy. Permanent AVB was seen in patients with ccTGA and DILV and after transcatheter closure of LV-RA VSD device implantation. Similarly, our patients with complete AVB were all diagnosed with ccTGA and DILV.

Few studies have analyzed the incidence of arrhythmia during cardiac catheterization. Bergersen et al.[13] reported a 4.2% incidence in diagnostic catheterization, whereas Cassidy et al.[14] reported a 3.4% incidence after diagnostic and interventional catheterization. Mehta et al.[15] studied 11,073 patients who underwent diagnostic and interventional catheterization, and the arrhythmia incidence was 1.7% (34 major, 164 minor complications) and accounted for 25% of all complications. Mori et al.[16] found an incidence of arrhythmia of 5.2%. The incidence of arrhythmia was 7% and the risk for development of major complication according to the ISNPCHD was 1.2% (n=16). Our arrhythmia incidence was higher than those reported in the literature, whereas the rate of the development of major complications was lower. The lower major complication rate might be related to the inclusion of only diagnostic cases. In addition, online database recording may have led to a high record of arrhythmia since all instances of arrhythmia, even minor ones, were recorded just at the end of the procedure. The use of this recording procedure prevents unintentional data loss and reveals its real incidence.

Studies of the management of arrhythmia after catheterization are limited in number. Spontaneous recovery, medical treatment, transient or permanent pacemaker implantation, and ECMO support are the reported treatment choices.[14–19]

Mehta et al.[15] reported incidence rates of 30% SVT and 28% AVB. The spontaneous recovery rate was 82%, while the other 18% of patients required transient pacemaker implantation. All first- and second-degree blocks were transient. Among 27 VT/VF episodes, 16 resolved with defibrillation, while 1 patient required ECMO support. In our study, 39% of all arrhythmias spontaneously recovered. Another 16% resolved with catheter manipulation. Eleven patients needed CPR. A total of 4 patients underwent pacemaker implantation (2 permanent, 2 transient). No patients required ECMO support. The differences in management strategies are probably related to the patients' diagnoses.

Study limitations

There are some limitations to our study. First, this was a retrospective, single-center study. Second, there were different operator groups during the study period because the facility is a training center. This may have resulted in differences in treatment approaches for arrhythmia. Third, the follow-up period was relatively short.

Conclusion

Many types of arrhythmia may develop during CHD catheterization. Life-threatening arrhythmias are not as rare as previously thought. Pediatric cardiologists should be ready for every kind of arrhythmia during an intervention. The appropriate management of these arrhythmias may have a positive effect on mortality and morbidity.

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