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Research Article / Araştırma Makalesi

Congenital Cardiac Malformations Associated with Dextrocardia: Analysis of 75 Patients in a Tertiary Center

Dekstrokardiye Eşlik Eden Doğumsal Kalp Hastalıkları: Üçüncü Basamak Bir Merkezde 75 Hastanın Analizi

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Abstract: Dextrocardia is a rare congenital anomaly. Careful examination is essential because of the coexistence of additional cardiac malformations that may require early treatment. The aim of this study is to evaluate the types and frequency of congenital cardiac malformations associated with dextrocardia. Patients who were diagnosed with dextrocardia were retrospectively examined in 51.045 children who had admitted to pediatric cardiology department. Clinical and echocardiographic findings as well as interventional and surgical procedures were analyzed. Of the total 75 cases, 60% were male. Median age at diagnosis was 2.95 months, (0 days-15,6 years). Situs inversus dextrocardia (SID) was found in 70,7% of cases, while situs solitus (SSD) and situs ambiguous dextrocardia (SAD) was found in 22,7% and 6,6%, respectively. Thirty-five (46,7%) patients had additional congenital heart disease (CHD). SAD was the most frequent subtype associated with additional CHD (100%) followed by SSD (76,5%) and SID (32,1%). Complex cardiac malformations including atrioventricular (AV) and ventriculoarterial discordance, malposition of great arteries, univentricular heart, AV valve and pulmonary atresia were detected. A total of 27 patients (36%) had undergone surgical or interventional procedures. Dextrocardia is closely associated with multiple complex CHDs that require surgical procedures. SID is more likely to have a structurally normal heart. SAD is definitely associated with additional CHDs, which are almost serious and complex defects. SSD usually has CHDs. Accurate identification of cardiac morphology with segmental analysis at early period of life is an important first step in improving the clinical course of patients. Thus, careful examination of heart structures via segmental analysis is essential in patients with dextrocardia.
Keywords: dextrocardia, atrial situs, congenital heart disease.

Özet: Dekstrokardi, nadir bir konjenital anomalidir. Erken tedavi gerektiren ek doğumsal kalp hastalıklarının eşlik edebilmesi nedeni ile iyi tanımlanmalıdır. Bu çalışmanın amacı dekstrokardiye eşlik eden doğumsal kalp hastalıklarının sıklığını ve tiplerini araştırmaktır. Pediatrik kardiyoloji birimimizde kayıtlı 51045 dosya geriye dönük incelenerek desktrokardi tanısı alan hastalar değerlendirildi. Klinik, ekokardiyografik bulgular ve yapılmış olan girişimsel ve cerrahi işlemler analiz edildi. Toplam 75 olgunun %60'ı erkekti. Tanı anında ortanca yaş 2,95 aydı. (0 gün-15,6 yaş). Olguların %70,7'sinde situs inversus dekstrokardi (SID), %22,7'sinde situs solitus dekstrokardi (SSD), %6,6'sında situs ambigus dekstrokardi (SAD) vardı. İlave doğumsal kalp hastalığı sıklığı tüm olgular ele alındığında %46,7'di. SAD %100 sıklıkla en sık ek doğumsal kalp hastalığı gözlenen dekstrokardi tipiydi. Bunu sırası ile SSD (%76,5) ve SID (%32,1) izlemekteydi. Atriyoventriküler ve ventriküloarteryel diskordans, büyük arter malpozisyonları, tek ventrikül, AV kapak ve pulmoner atrezi gibi kompleks doğumsal kalp hastalıkları saptandı. Yirmi altı hastada (%34,7) kardiyak cerrahi işlemler uygulanmıştı. Dekstrokardi, cerrahi gerektiren doğumsal kalp hastalıkları ile yakın ilişkilidir. SID, normal yapısal kalp saptanması olasılığı en yüksek olan alt tiptir. SAD'ye ise mutlaka, hemen hemen daima önemli ve kompleks defektler olan doğumsal kalp hastalıkları eşlik eder. SSD'ye ek doğumsal kalp hastalığı yüksek oranda eşlik eder. Yaşamın erken döneminde kardiyak morfolojinin segmental analizle doğru bir şekilde tanımlanması, hastaların klinik seyrinin iyileştirilmesinde önemli bir ilk adımdır. Bu nedenle, kardiyak yapıların segmental ekokardiyografik analiz ile detaylı değerlendirilmesi dekstrokardik hastalarda gereklidir.
Anahtar Kelimeler: dekstrokardi, atrial situs, doğumsal kalp hastalığı.

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1. Introduction

The right-sided embryologic development of the heart, with most of the heart mass positioned in the right hemithorax is defined as dextrocardia (1). The diagnosis may occur during a routine physical examination or after a routine chest X-ray without any cardiac symptoms. However, it can be diagnosed during further evaluations that is made due to signs and symptoms of simple or complex congenital malformations (1, 2). Additional congenital cardiac malformations that may require medical or surgical treatment may occur in association with this arrangement (1-3). Although it is rare, it must be well recognized by health practitioners because of high frequency of additional cardiac malformations that may require early appropriate treatment (2, 4). The aim of this study is to evaluate the types and frequency of congenital cardiac malformations associated with dextrocardia.

2. Materials and Methods

Study Design

This retrospective study was conducted at Van Education and Research Hospital, Department of Pediatric Cardiology, Van, Turkey, for a study period from October 2014 to September 2018. Institutional ethics committee approved the study on 4 October 2018 (Approval No: 2014/18). Additionally, the study was conducted in accordance with Helsinki Declaration. Children who were diagnosed with dextrocardia were searched in a large population consisting of 51,045 children during the study period. Clinical findings, catheterization reports and surgical records were re-analyzed. Echocardiographic reports including the results of detailed segmental analysis of cardiac structures were examined. Reports without segmental analysis were excluded.

Dextrocardia was defined as congenitally right sided heart, with a major axis pointing to the right as a result of embryologic development (1, 5), whereas other right sided hearts due to secondary causes were not included. Situs was defined as solitus in the presence of normal visseroatrial arrangement and inversus as a mirror image of normal arrangement. Situs ambiguous was defined if the sidedness of visceroatrial organs were random or in other words, in the situation of undetermined situs. Additionally, situs ambiguous was furtherly classified as right and left isomerism (1, 2, 6).

Statistical Analysis

The statistical analysis was performed using Statistical Package for Social Sciences Software, version 21. Demographic and clinical variables were summarized with descriptive statistics. Categorical variables were summarized as absolute frequency and percentage, whereas continuous variables were summarized as median, mean and standard deviation.

3. Results

Seventy-five patients over 51,045 cases (0.14%) were diagnosed with dextrocardia during the study period of 7 years. There was a male predominance (60%, n:45). The mean and median age at diagnosis was 3.01±4.77 years and 2.95 months, respectively (range: 0 days-15.6 years). Fifty-three cases (70.7%) were diagnosed with situs inversus dextrocardia (SID) while 17 cases (22.7%) and 5 cases (6.6%) were diagnosed with situs solitus (SSD) and situs ambiguous dextrocardia (SAD), respectively. In addition, 4 cases (5.3% of total) of SAD had right atrial isomerism (RAI) and 1 case (1.3% of total) had left atrial isomerism (LAI). Thirty-five (46.7%) patients had additional congenital cardiac malformations, and 27 (77.1%) of them were cyanotic. The most frequent associated congenital cardiac malformation was ventricular septal defect (41.3%, Table 1). A total of 27 patients (36%) had undergone surgical or interventional procedures (Table 2).

Situs inversus dextrocardia was the largest subtype (70,7%, n:53) and most of them were male (58.5%, n:31). Mean and median ages at diagnosis were 3.63±5.04 years and 6.17 months, respectively (range: 0 days-15,6 years). Seventeen (32,1%) patients had additional congenital cardiac malformations and 22,6% of them had cyanosis. Results of segmental echocardiographic analysis of the

patients are shown on table 1. Thirteen (24,5%) cases had undergone palliative or corrective surgery (Table 2).

Situs solitus dextrocardia was the second largest subtype (22,7%, n:17) and 64,7% (n:11) of them were male. Mean and median ages at diagnosis were 1.85±4.21 years and 6 days, respectively (range:0 day-13,2 years). Thirteen (76,5%) patients had various associated congenital cardiac malformations while 64,7% had cyanosis. Results of segmental echocardiographic analysis of the patients are shown on table 1. Ten cases (58,8%) had undergone palliative or corrective surgery (Table 2).

Situs ambiguous was present in 5,6% of all. Three of them (60%) were male. Four cases (80%) had RAI whereas the remaining one (%20) had LAI. Mean and median ages at diagnosis were 5.45±12.02 months and 3 days, respectively (range:1 day-2.25 years). All of the patients (100%) had various additional congenital cardiac malformations while 80% had cyanosis. Results of segmental echocardiographic analysis of the patients are shown on table 1. Three cases (60%) had undergone palliative or corrective surgery, one of whom had undergone transcatheter ductal stent implantation previous to Glenn anastomosis (Table 2). The remaining two (40%) also required surgical intervention and are waiting for the procedure.

Table 1. Echocardiographic findings of patients in accordance with atrial situs.

Characteristics		Situs Inversus n:53, (%)	Situs Solitus n:17, (%)	Situs Ambiguous n:5, (%)	Total n:75 (%)
AV connection	*Concordance*	52 (98.1%)	14 (82.4%)	4 (80%)	70 (%)
	Discordance	1 (1.9%)	2 (11.8%)	1 (20%)	4 (5.3%)
	DILV	0	1 (5.9%)	0	1 (5.9%)
AV valves	*Two patent AV valves*	46 (86.8%)	14 (82.4%)	2 (40%)	62 (82.6%)
	Common AV valve	4 (7.5%)	1 (5.9%)	3 (60%)	8 (%10.6)
	Single AV valve	3 (5.7%)	2 (11.8%)	0	5 (6.6%)
VA connection	*Concordance*	42 (79.2%)	7 (41.2%)	1 (20%)	50 (66.6%)
	Discordance	5 (9.4%)	7 (41.2%)	1 (20%)	13 (17.3%)
	DORV	6 (11.3%)	2 (11.8%)	3 (60%)	11 (14.6%)
	Single great artery	0	1 (5.9%)	0	1(5.9%)
Great artery relation	*Normal*	46 (86.8%)	7 (41.2%)	3 (60%)	56 (74.6%)
	d-malposition	6 (11.3%)	3 (17.6%)	1 (20%)	10 (%13.3)
	l-malposition	1 (1.9%)	4 (23.5%)	1 (20%)	6 (%8)
Pulmonary blood flow	*Normal*	39 (73.6%)	7 (41.2%)	1 (20%)	47 (%62.6)
	Decreased	5 (9.4%)	8 (47.1%)	3 (60%)	16 (%21.3)
	Increased	9 (17%)	2 (11.8%)	1 (20%)	12 (%16)
Septal Defects	*VSD*	14 (26.4%)	13 (76.5%)	4 (%80)	31 (%41.3)
	ASD	16 (30.2%)	9 (52.9%)	4 (%80)	29 (38.6%)
	Pulmonary Stenosis	5 (9.4%)	6 (35.3%)	3 (60%)	14 (18.6%)
	PDA	7 (13.2%)	1 (5.9%)	1 (20%)	9 (12%)
Additional findings	Pulmonary atresia	2 (3.7%)	2 (11.7%)	1 (20%)	5 (6.6%)
	AV valve insufficiency	3 (5.7%)	2 (11.7%)	0	5 (6.6%)
	Bilateral SVC	1 (1.9%)	1 (5.9%)	1 (20%)	3 (4%)
	TAPVC	0	0	2 (40%)	2 (2.6%)
	Aortic valve insufficiency	1 (1.9%)	1 (5.9%)	0	2 (2.6%)

Abbreviations: ASD: atrial septal defect, AV: atrioventricular, DILV: double inlet left ventricle, DORV: double outlet right ventricle, PDA: patent ductus arteriosus, SVC: superior vena cava, TAPVC: total anomalous pulmonary venous connection, VA: ventriculoarterial, VSD: ventricular septal defect.

Table 2. Surgical and interventional procedures performed in patients.

Surgial procedure	Situs Inversus n (%)	Situs Solitus n (%)	Situs Ambigunous n (%)	Total n (%)
Modified Blalock-Taussig shunt	2 (3.8 %)	2 (11.8%)	0	4 (5.3%)
Glenn shunt	1 (1.9%)	4 (23.5%)	1 (20%)	6 (8%)
Total corrective surgery	6 (11.3)	2 (11.8%)	1 (20%)	9 (12%)
Jaten operation	4 (7.5%)	1 (5.9%)	1 (20%)	6 (8%)
Ductal stenting	0	0	1 (20%)	1 (1.3%)
Fontan operation	0	1 (5.9%)	0	1 (1.3%)

4. Discussion

Dextrocardia, is a rare congenital malformation with reported incidence of 0.40-0.83 per 10,000 births in various studies (1, 7). In our study the incidence of dextrocardia was 0.14% in patients who admitted to pediatric cardiology department accounting for about 0.86 per 10,000 live births during study period in the province of eastern region of Turkey with a total population of approximately 2 million. This was slightly higher than the studies previously reported. There was a male preponderance in our study compatible with the literature (2, 3). Various additional congenital malformations which may require surgical or transcatheter interventions are common in dextrocardia (1-3). In our study, a total of 27 patients (36%) had palliative or corrective surgical or interventional procedures due to associated congenital heart disease (CHD). For this reason, careful clinical and cardiac examination must be performed for all patients with dextrocardia. Echocardiographic evaluation can be challenging in this patients as the right sided heart require unique positions and manipulations of the echocardiography probe. Therefore, the echocardiographic assessment should be structured via segmental analysis, including systematical establishing of the situs, evaluation of morphological configuration of heart chambers, atrioventricular and ventriculoarterial relationships, systemic and pulmonary outflows and relationship of great arteries and additional cardiac and extracardiac abnormalities (1, 2).

Situs inversus dextrocardia was the most common subtype of dextrocardia in our series accounting for 70,7% of cases followed by SSD (22,7%), whereas SAD was very rare (6,6%). SSD had been reported as the commonest subtype of dextrocardia before a couple of decades (8-10) whereas, this knowledge has been changed with recent reports. Garg et al (2) concluded that this shift is probably due to the situation of that most of the patients with SID have structurally normal heart, which evades detection. In their study, all three subtypes of dextrocardia was reported to be close to each other with a slight predominance of SID (39,2%) followed by SSD (34,4%) and SAD (26,4%). Compatible with Garg et al's study, Bohun et al (1) reported similar incidences of subtypes of dextrocardia close to each other again with a slight preponderance of situs inversus (1). Comparison of results of studies reported regarding the situs is shown on table 3. In contrast to the studies reported in the literature we found a high predominance of SID and a very rare incidence of SAD. This may be due to the differences in age of study population between the studies. Confirming this, Bohun at al's (1) population was mostly antenatal diagnosed, while mean age was 9.12 ±11.2 years (range: 3 days-60 years) in Garg at al's (2) study and median age was 20 months (range: prenatal to 12 years) in Evans et al.'s study (3). The median age of our patients at diagnosis was 2.95 months (range: 0 days-15,6 years). In addition, Bohun et al (1) have concluded that SID may have been underrepresented in their study group, because of the lack of additional pathology related with this subtype of situs. The incidence of additional cardiac malformation with SID is thought to be lower than other subtypes, especially if the AV connection is concordant (2). In our study, about 1/3 of patients with situs inversus had additional cardiac malformation. Similar to our study Bohun et

al (1) reported an incidence of 23% whereas Roodpeyma et al (11) reported this as 50%. In contrast, Garg et al. (2) reported a high incidence of 72,1% and concluded that this high incidence is related with their study population, as their center was a tertiary referral center and also added that their findings were similar to some other referral centers (12) and autopsy studies (13). Atrial septal defect (%) and ventricular septal defect (%) were the most CHDs in our series. Regarding the segmental analysis, most of our patients with SID had a concordant atrioventricular (AV) connection and ventriculoarterial (VA) relation and normal great artery relationship with normal pulmonary and systemic blood flow. In addition, if the AV connection is concordant the possibility of normally structured heart is also increased. These findings were similar to previous reports in the literature (1-3, 10). AV connection was discordant only in one patient with SID who had congenitally corrected transposition of great arteries, ventricular septal defect, atrial septal defect and pulmonary stenosis. In a recently published study, Tripathi et al. has reported double outlet right ventricle as the most common CHD (27.1%) followed by simple left to right shunt lesions (16%) in patients with situs inversus dextrocardia (14).

Situs solitus dextrocardia is usually associated with additional CHD (1-3, 8-10, 13). Additional CHD in SSD is reported as 93% and 96% in the literature (1, 2). We observed a lower incidence of additional CHD (76,5%) in the present study. The most frequent connection abnormality was discordance of VA connection and great artery malposition, and both of them accounted for 41,2% separately, which is compatible with the previously reported series (1, 2). In addition, near half of the patients with SSD in the present series had a decreased pulmonary blood flow. Tripathi et al. reported that corrected transposition of great arteries is the most common morphologic abnormality (31,3%) followed by double outlet right ventricle (22,1%), in patients with situs solitus dextrocardia (14).

Therefore, almost 2/3 of these patents had central cyanosis. Ten (58,8%) patients with SSD had undergone surgery including palliative shuts, arterial switch, Fontan operation and various total corrective surgeries.

It is reported that all cases with situs ambiguous dextrocardia have multiple and complex CHDs (2, 15, 16). Our series reconfirms this knowledge with an incidence of CHD in SAD to be 100%. Although, 80% of cases with SAD had a concordant AV connection, only 20% had a concordant VA connection. Two (40%) cases had great artery malposition whereas double outlet right ventricle was present in three (60%). Total abnormal pulmonary venous connection was detected only in SAD group with an incidence of 40%. All of the patients required surgical interventions in which 3 of them had undergone surgery and transcatheter interventions including, systemic to pulmonary artery shunts, arterial switch operation, surgical VSD closure and ductal stenting, and the remaining two were waiting for surgery.

The most common cardiac malformation in SSD and SAD subtypes was ventricular septal defect similar to study of Bohun et al (1). In contrast to their study, ASD was the most common defect in SID group with an incidence of 30,2%, which was slightly more common than VSD (26,4%). As both septal defects are commonly seen congenital heart defects (17, 18), this result can be expected.

Table 3. Comparison of situs arrangement in patients with dextrocardia in the literature.

Literature	Situs inversus n (%)	Situs solitus n (%)	Situs ambiguous n (%)	Total n
Evans et al.[3]	30 (49%)	20 (33%)	11 (18%)	61
Garg et al.[2]	49 (39%)	43 (34%)	33 (27%)	125

Bohun et al.[1]	30 (37%)	27 (33%)	24 (30%)	81
Roodpeyma et al.[11]	8 (57%)	4 (29%)	2 (14%)	14
Tripathi et al.[14]	144 (38.1%)	163 (43.1%)	71 (18.8%)	378
The current study	53 (70.7%)	17 (22.7%)	5 (6.6%)	75

5. Conclusion

Dextrocardia is closely associated with additional congenital cardiac malformations which include multiple complex structural abnormalities that may require early surgical or transcatheter procedures. SID is much more likely to have a structurally normal heart. SAD is definitely associated with additional CHDs, which are almost serious and complex defects. SSD is likely to have additional CHDs but it may have also a normally structured heart. As surgical and transcatheter procedures have been developed with high success rates, an early and structurally well-defined diagnosis is essential in patients with dextrocardia to provide an appropriate treatment for an improved outcome. Thus, careful examination of all cardiac segments and structures via segmental analysis is essential for each patient with dextrocardia (14).

REFERENCES

1. Bohun CM, Potts JE, Casey BM, Sandor GG. A population-based study of cardiac malformations and outcomes associated with dextrocardia. *Am J Cardiol* 2007;100:305-9.
2. Garg N, Agarwal BL, Modi N, et al. Dextrocardia: an analysis of cardiac structures in 125 patients. *Int J Cardiol* 2003;88:143-55.
3. Evans WN, Acherman RJ, Collazos JC, et al. Dextrocardia: practical clinical points and comments on terminology. *Pediatr Cardiol* 2010;31:1-6.
4. Maldjian PD, Saric M. Approach to dextrocardia in adults: review. *AJR Am J Roentgenol* 2007;188:39-49.
5. Arcilla RA, Gasul BM. Congenital dextrocardia. Clinical, angiocardiographic, and autopsy studies on 50 patients. *J Pediatr* 1961;58:39-58.
6. Ghosh S, Yarmish G, Godelman A, et al. Anomalies of visceroatrial situs. *AJR Am J Roentgenol* 2009;193:1107-17.
7. Kidd SA, Lancaster PA, Mccredie RM. The incidence of congenital heart defects in the first year of life. *J Paediatr Child Health* 1993;29:344-9.
8. Calcaterra G, Anderson RH, Lau KC, Shinebourne EA. Dextrocardia--value of segmental analysis in its categorisation. *Br Heart J* 1979;42:497-507.
9. Squarcia U, Ritter DG, Kincaid OW. Dextrocardia: angiocardiographic study and classificiation. *Am J Cardiol* 1973;7:965-77.
10. Huhta JC, Hagler DJ, Seward JB, et al. Two-dimensional echocardiographic assessment of dextrocardia: a segmental approach. *Am J Cardiol* 1982;50:1351-60.
11. Roodpeyma Sh AM. Dextrocardia in children: Review of 15 cases. *Iranian Journal of Pediatrics* 1999;1:41-7.
12. Ayres SM, Steinberg I. Dextrorotation of the Heart. An Angiocardiographic Study of Forty-One Cases. *Circulation* 1963;27:268-74.
13. Stanger P, Rudolph AM, Edwards JE. Cardiac malpositions. An overview based on study of sixty-five necropsy specimens. *Circulation* 1977;56:159-72.
14. Tripathi S, Ajit Kumar VK. Comparison of Morphologic Findings in Patients with Dextrocardia with Situs Solitus vs Situs Inversus: a Retrospective Study. *Pediatr Cardiol* 2019;40:302-9
15. Rose V, Izukawa T, Moes CA. Syndromes of asplenia and polysplenia. A review of cardiac and non-cardiac malformations in 60 cases withspecial reference to diagnosis and prognosis. *Br Heart J* 1975;37:840-52.
16. De Tommasi S, Daliento L, Ho SY, et al. Analysis of atrioventricular junction, ventricular mass, and ventriculoarterial junction in 43 specimens with atrial isomerism. *Br Heart J* 1981;45:236-47.
17. Hoffman JI. Incidence of congenital heart disease: I. Postnatal incidence. *Pediatr Cardiol* 1995;16:103-13.
18. Hoffman JI. Incidence of congenital heart disease: II. Prenatal incidence. *Pediatr Cardiol* 1995;16:155-65.