Cardiology and Angiology: An International Journal

9(3): 46-56, 2020; Article no.CA.59581
ISSN: 2347-520X, NLM ID: 101658392

An analysis of Atrioventricular Canal Defect (AVCD) in Children in the Niger Delta Region of Nigeria, West Africa

P. N. Tabansi[1*] and B. E. Otaigbe[1]

[1]Department of Paediatrics and Child Health, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author PNT wrote the protocol and the first draft of the study, managed the literature searches and performed the statistical analysis. Author BEO designed the study and managed the analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CA/2020/v9i330142
Editor(s):
(1) Gen-Min Lin, National Defense Medical Center, Taiwan.
Reviewers:
(1) Vikrant Vijan, Vijan Hospital and Research Center, India.
(2) Jiatuo-Xu, Shanghai University of Chinese Medicine, China.
Complete Peer review History: http://www.sdiarticle4.com/review-history/59581

Original Research Article

Received 06 June 2020
Accepted 09 August 2020
Published 10 August 2020

ABSTRACT

Aims: This was to determine the demographic and echocardiographic characteristics of AVCD patients and analyse the types of defect associated with the presence or absence of obvious phenotypic syndromes in children in the Niger Delta region of Nigeria.
Methodology: It is a prospective study of children with AVCD seen over a 5 years period. Data on age, gender, presence or absence of chromosomal/genetic syndrome, age at onset of symptoms and age at presentation to the hospital, parental age, echocardiographic description, and outcome were analysed.
Results: Eighty-one cases of AVCD were analyzed with a male to female ratio of 1.1:1. Age ranged from birth to five years with a Mean Age of 5.5 months and Mode 3 months. There were more non-syndromic patients 46(56.8%) compared to 35(43.2%) patients with features of chromosomal syndrome. Complete AVCD with a common atrioventricular valve was the commonest findings in syndromic and non-syndromic children. Transitional AVCD was seen only in syndromic patients. Non-syndromic patients had more complex additional cardiac anomalies.

**Corresponding author: E-mail: petronila.tabansi@uniport.edu.ng;*

Conclusion: That more than 50% of cases of AVCD seen were in non-syndromic children in the Niger Delta is worrisome because this is an oil exploratory region known for constant gas flaring and environmental pollutants.

Keywords: Atrio-ventricular canal defect; echocardiographic analysis; Niger Delta of Nigeria.

1. INTRODUCTION

Congenital heart defects (CHD) are the leading cause of birth defect-related mortality and their etiology is poorly understood.[1,2] Atrio-ventricular canal defect (AVCD) constitute 2% to 3% of all congenital heart diseases [2,3] and results from developmental abnormalities of the endocardial cushion-derived components of the atrial and ventricular septae leading to an ostium primum Atrial Septal Defect (ASD), an unrestrictive inlet Ventricular Septal Defect (VSD) and clefts in the anterior mitral valve and septal leaflet of the tricuspid valve.[2,3] When all these lesions are present it results in a single common atrioventricular valve (AV-valve) ring and this type is called Complete AVCD.[2,3] In Transitional AVCD, there is an ostium primum ASD, cleft of the anterior mitral valve and the septal leaflet of the tricuspid valve, and a restrictive VSD.[4,5,6] In Partial AVCD, an ostium primum ASD is present with two separate atrio-ventricular valve (AV-valve) orifices into the ventricles, and no VSD.[3] Rare types of partial AVCD include a common atrium; inlet VSD (canal-type VSD); and isolated cleft of the mitral valve.[3] Presence of these defects result in intracardiac shunts and mixing of oxygenated and deoxygenated blood at atrial and ventricular levels. There may also be left ventricular to the right atrial shunts.[3]

Complete AVCD is the commonest type seen and the common AV-valve usually has five leaflets including an anterior and posterior bridging leaflets [2,3,6]. The anterior bridging leaflet straddles in its attachment to the papillary muscles and this has been classified into Type A, B, and C by Rastelli [3,7]. Complete AVCD may also be classified as “Balanced AVCD” when the common AV-valve is equally committed to the two ventricles; or “Unbalanced AVCD” when the common AV-valve is predominately committed to one ventricle (right or left ventricular dominance) [3,6].

About 70% of all cases of complete AVCD have Down’s Syndrome [3,8] and half of all Down’s Syndrome patients with CHD have AVCD.[3,6] AVCD appears to be relatively uncommon in non-syndromic children and there is limited data on characteristics of non-syndromic AVCD.[9] However, some sociodemographic and reproductive factors such as maternal diabetes and maternal obesity have been implicated as risk factors for AVCD in non-syndromic children [9]. Associated cardiac anomalies with AVCD include Tetralogy of Fallot (TOF), Patent ductus arteriosus (PDA), Ostium Secundum ASD and other rarer lesions. AVCD is also seen in heterotaxia [3,6,10].

The natural history of AVCD includes premature death due to complications of congestive heart failure and/or pulmonary artery hypertension.[6] Whether syndromic or non-syndromic, about 50% of children with AVCD die in infancy as mortality rate is similar for both groups.[2,10] Repair during infancy is recommended as this minimizes the risk of premature death or pulmonary vascular obstructive disease.[3,6] Although there abounds literature on CHD in Nigeria,[11-14] focused report on AVCD and its characteristics in an African population is lacking. This study thus aims to provide an analysis of AVCD in children in the Niger Delta Region of Nigeria, an area marred by environmental pollution;[15-18] and highlight its features and echocardiographic characteristics.

2. MATERIALS AND METHODS

This is a prospective study of children presenting with CHD with echocardiographic diagnosis of AVCD, over a five-year period from January 2015 to December 2019. Participants were recruited from the Paediatric Cardiology Specialist Clinics of the University of Port Harcourt Teaching Hospital, and a private Paediatric Cardiology Specialist hospital, both in Port Harcourt City, located in the Niger-Delta Region of Southern Nigeria. Information sought included age at onset of symptoms, age at presentation in the hospital, gender, weight, clinical features and parental ages. The children were then examined for presence or absence of chromosomal syndrome/dysmorphism especially Down’s syndrome. Patients with Down’s syndrome were identified using documented physical stigmata[19] on physical examination including: presence of Short stature, Microcephaly, Global hypotonia, Upward slanting

eyes, Low set ears, Hypertelorism, Prominent epicanthal folds, Brachycephaly, Third fontanelle, Small mouth, Protruding tongue, Brachydactyly (Short stubby fingers), Simian crease on palm, Clinodactyly, Sandal toes, Brushfield spots. The presence of three or more of these features is suggestive of down Syndrome [19] Pulse oximetry was done to determine the oxygen saturation (SPO2). Echocardiography was also done and the types of AVCD, and other cardiac anomalies present were documented. The outcome of the patient at the end of the study period was also documented.

2.1 Statistical Analysis

All data were entered into a database. Data analysis was done using Microsoft Excel and SPSS version 25. Results are presented as tables and charts; cross analysis was done using chi-square test and a p-value <0.05 was considered significant.

3. RESULTS

Of the 2054 children who presented to the two Paediatric Cardiology specialist clinics during the study period, 81 had AVCD constituting 3.9% of all congenital heart diseases.

3.1 Age and Gender Distribution of Study Population

The study population age ranged from birth (0 months) to 5 years with a Mean age of 5.5 months and Mode of 3 months. There were 43 males and 38 females giving a male female ratio of 1:1.1.

3.2 Proportion of Syndromic to Non-syndromic Children in the Study Population

A higher proportion of the study population had normal features (Non-syndromic) compared to those with dysmorphic features suggestive of a chromosomal syndrome (Syndromic). The ratio of non-syndromic to syndromic children was 1.3:3. This is illustrated in Fig. 1. All the syndromic patients had Down's syndrome.

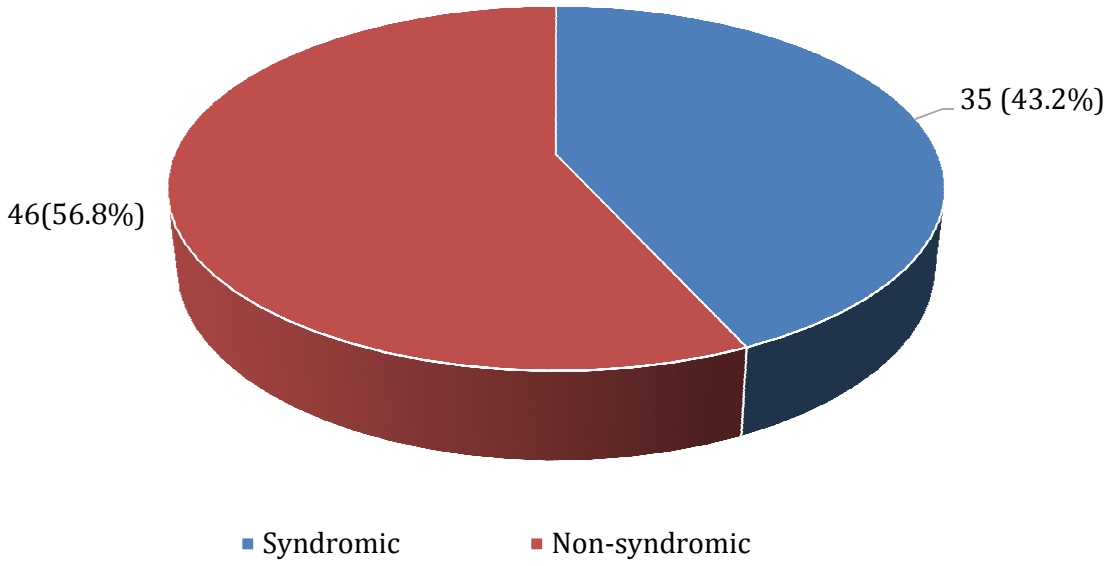

Fig. 1. Proportion of syndromic to non-syndromic children in the study population

3.3 Age at Onset of Symptoms According to Presence or Absence of Syndrome

Most of the study population 70 (86.4%) had onset of symptoms before or by three months of age. Of these, 32 (39.5%) were syndromic while 38(46.9%) were non-syndromic. More than 90% of the study population were symptomatic by six months of age as shown in Table 1.

Table 1. Age at onset of symptoms according to presence or absence of syndrome

Age (months)	Syndromic		Non-syndromic		Total (age)	Percentage (%)
	Male	Female	Males	Females		
0 – 3	18	14	21	17	70	86.4
4 – 6	0	1	3	0	4	5.0
7 – 9	0	0	0	1	1	1.2
10- 12	0	0	0	1	1	1.2
13 - 15	0	0	0	0	0	0
16 - 18	0	0	0	0	0	0
19 - 21	0	0	0	0	0	0
22 -24	0	0	0	0	0	0
>24	0	2	1	2	5	6.2
Total	**18**	**17**	**25**	**21**	**81**	**100**
Grand Total	**35**		**46**		**81**	**100**

Table 2. Age at presentation to the hospital according to presence or absence of syndrome

Age (months)	Syndromic		Non-syndromic		Total	Percentage (%)
	Males	Females	Males	Females		
0 – 3	6	5	12	7	30	37.0
4 – 6	6	7	8	2	23	28.4
7 – 9	2	0	1	3	6	7.4
10- 12	0	2	0	3	5	6.2
13 - 15	0	1	1	2	4	5.0
16 - 18	0	0	0	0	0	0.0
19 - 21	0	0	0	1	1	1.2
22 -24	1	0	0	0	1	1.2
>24	3	2	3	3	11	13.6
Total	18	17	25	21	81	100
Grand total	35		46		81	100

3.4 Age at Presentation at the Hospital According to Presence or Absence of Syndrome

The age at presentation to the hospital according to presence or absence of syndrome is illustrated in Table 2. In total, only 30(37%) patients presented to the hospital by three months of age. Of these, 19 (23.5%) were non-syndromic while 11(13.5%) were syndromic. By six months of age, the proportion of those who presented at the hospital increase to 53(65.4%) of which 24 (29.6%) were syndromic and 29 (35.8%) were non-syndromic.

3.5 Comparison of Age at Onset of Symptom and Age at Presentation in Hospital

A comparison of the age of the study population at onset of symptoms and their age at eventual presentation at the hospital shows a significant delay in presentation to the hospital from the time of symptom onset. (χ^2 = 189.97; p = 0.00). This is illustrated in Fig. 2.

3.6 Parental Sociodemographic Characteristics

Table 3 reveals that greater than 35% of the mothers and 60% of the fathers were over 35 years. Mothers above 35 years had more children within the “syndromic AVCD” subset. However, there was no significant difference between maternal age and presence of syndromic or non-syndromic AVCD. (χ^2 =15.000; p= 0.241). Fathers above 35 years had more children within the “non-syndromic AVCD” subset. However, there was no significant difference between paternal age and presence of syndromic or non-syndromic AVCD. (χ^2= 15.000; p=0.241).

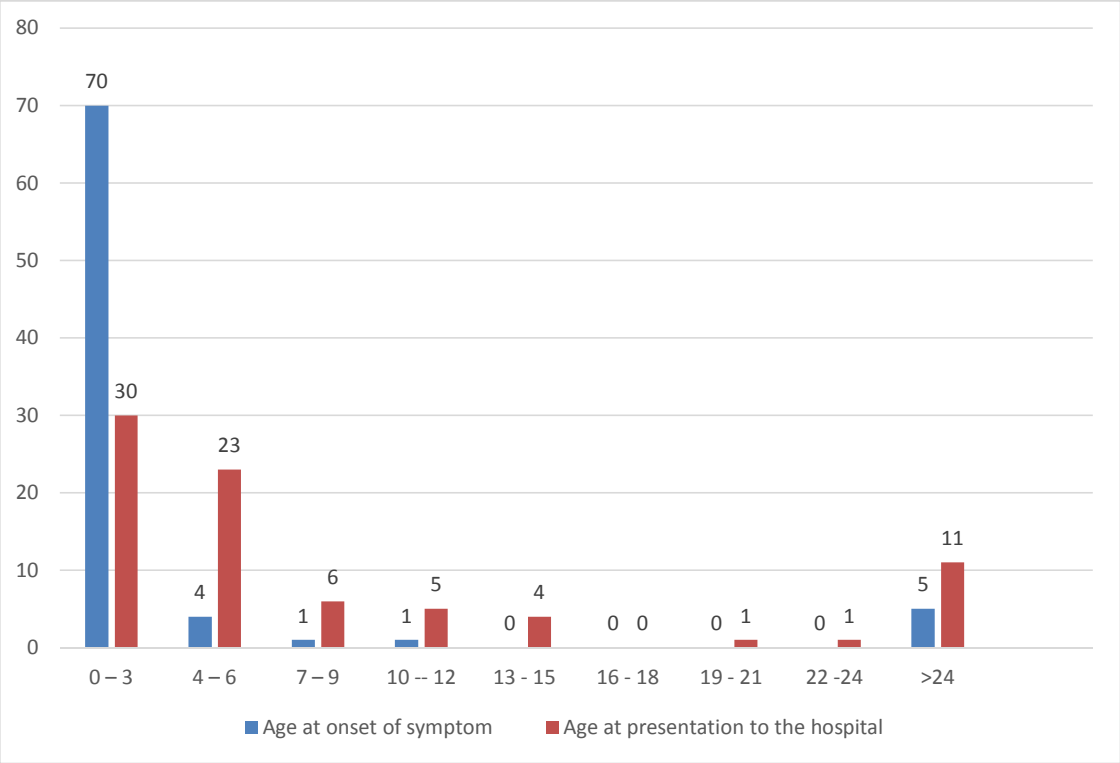

Fig. 2. Comparison of age at onset and age at presentation in hospital

Table 3. Parental sociodemographic characteristics

Variables	Syndromic children with AVCD	Non-syndromic children with AVCD child	Total	Percentage (%)
Maternal Age (years)				
≤ 25	4	7	11	13.5
26 - 30	5	16	21	25.9
31 - 35	6	13	19	23.5
36 – 40	13	7	20	24.7
≥ 41	7	3	10	12.4
Total	**35**	**46**	**81**	100
Paternal Age				
≤ 25	0	1	1	1.2
26 - 30	3	6	9	11.2
31 - 35	7	10	17	21.0
36 – 40	8	19	27	33.3
≥ 40	17	10	27	33.3
Total	**35**	**46**	**81**	100

3.7 Clinical Features Seen in Study Population

Fast breathing, effort intolerance and failure to thrive accounted for over 80% of symptoms; while cardiac murmur and cyanosis accounted for over 30% of signs. The least common reported symptom was cough 1(1.2%). One third of the study population had multiple clinical features (Table 4).

3.8 Oxygen Saturation (SPO_2) of the Study Population

Only a minority of patients 10(12.3%) had normal SPO_2 of 97% and above. More than half of the

syndromic children had moderate to severe reduction in SPO_2 (< 90%) as depicted in Table 5.

3.9 Types of AVCD Seen in Syndromic and Non-syndromic Patients

Fig. 3 illustrates the different types of AVCD seen in syndromic and non-syndromic patients in the study population. Overall, complete AVCD was the most common type seen 76 (93.9%) followed by partial AVCD 4(4.9%), then Transitional AVCD 1(1.2%). Of those with complete AVCD, 7 (9.2%) had unbalanced AVCD. More specifically, 33 (94.3%) of the 35 syndromic patients had complete AVCD; while of the 46 non-syndromic children, 43 (91.3%), had complete AVCD. Partial AVCD was more common in non-syndromic 3(3.7%) compared to 1 (1.2%) in syndromic children. The only case 1(1.2%) of Transitional AVCD was seen in a syndromic patient. These differences were not statistically significant (χ = 4.581, p = 0.205).

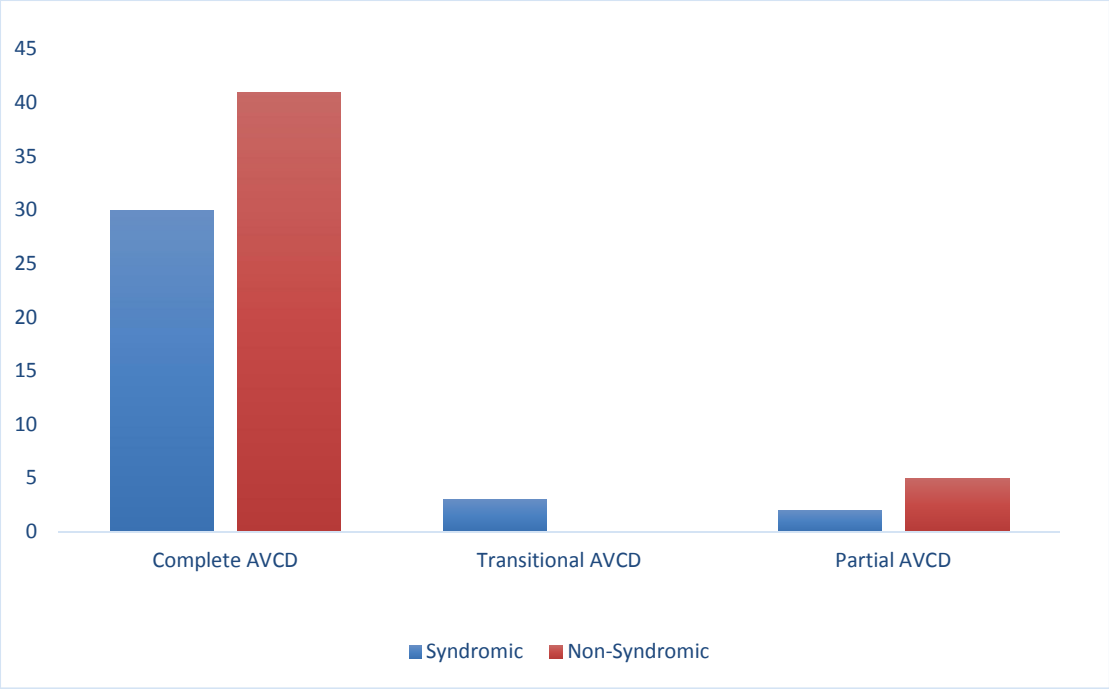

Fig. 3. Types of AVCD seen in study population

Table 4. Clinical features seen in study population

Clinical Features	Frequency	Percentage (%)
SYMPTOMS		
Fast Breathing	39	48.1
Effort intolerance	15	18.5
Failure to thrive	12	14.8
Fever	3	3.7
Cough	1	1.2
SIGNS		
Cardiac murmur	15	18.5
Cyanosis	11	13.6
Dysmorphism	6	7.4
Multiple features	27	33.3

**Multiple representation applies*

Table 5. Oxygen saturation (SPO_2) values of the study population according to dysmorphism

SPO2 (%)	Syndromic	Non-Syndromic	Total	Percentage (%)
≥ 97	2	8	10	12.3
96 - 93	9	8	17	21.0
93 - 90	4	15	19	23.5
89 - 86	10	9	19	23.5
≤ 85%	10	6	16	19.7
Total	**35**	**46**	**81**	**100**

Table 6. Other Cardiac Anomalies detected in study population

Cardiac Anomalies	Syndromic	Non-Syndromic	Total	Percentages (%)
Simple				
PDA	17	28	45	55.6
Pulmonary Stenosis	6	23	29	35.8
OS – ASD	3	1	4	4.9
Pericardial Effusion	4	1	5	6.2
PAH	30	25	55	67.9
Complex				
TAPVC	0	3	3	3.7
Single Ventricle with Common atrium	2	5	7	8.6
Dextrocardia	0	5	5	6.2
TGA	1	3	4	4.9
Truncus Arteriosus	0	1	1	1.2
AP -window	0	1	1	1.2
DORV	1	6	7	8.6

**Multiple representation applies, PDA – Patent Ductus Arteriosus; TGA – Transposition of the Great Arteries; RVOTO – Right ventricular outflow tract obstruction; OS-ASD – Ostium Secundum ASD; PAH – Pulmonary Hypertension; AP-window- Aorto-Pulmonary Window TAPVC – Total Anomalous Pulmonary Venous Drainage; DORV – Double Outlet Right Ventricle*

Table 7. Outcome of study population (test of significance)

Outcome	Syndromic	Non-syndromic	Total	Percentage (%)
On medical therapy	18	24	42	51.9
Lost to follow up	11	10	21	25.9
Surgical correction	2	4	6	7.4
Died	4	8	12	14.8
Total	**35**	**46**	**81**	**100**

3.10 Other Cardiac Anomalies Detected in the Study Population

Table 6 shows that PDA was the most common additional (simple) cardiac anomaly detected in both syndromic and non-syndromic patients occurring in 55.6% of the study population. Pulmonary stenosis was seen in half (23) of all non-syndromic patients. Over 85% of the syndromic patients had pulmonary hypertension (PAH). Non-syndromic patients had more additional (complex) cardiac lesions.

3.11 Outcome of Study Population

The outcome of the follow up the study population reveals that only a minority of cases 6(7.4%) had surgical correction of their AVCD, of which non-syndromic patients constituted a higher proportion 4(4.9%). Twelve patients died giving a mortality of 14.8%. However, the specific mortality rate within the syndromic and non-syndromic groups were 11.4% and 17.4% respectively. This is shown in Table 7.

4. DISCUSSION

The study reveal that AVCD constituted 3.9% of all cases of CHD seen in the study period which is higher than the 2% to 3% documented in most literature.[2,3] This is possibly due to the fact that this study recruited patients from paediatric cardiology specialist centers with a high referral rate from peripheral and non-specialist hospitals for cardiac evaluation and care.

Interestingly, this study found that a higher proportion of patients with AVCD were non-syndromic at 56.8% compared to 43.2% of syndromic cases. All the syndromic patients had Down's Syndrome. Although this difference was not statistically significant, it is an unusual finding as most cases of AVCD in literature suggest that it occurs more commonly in children with Down's Syndrome [2,3,6,8,9]. The explanation of this finding may also lie in the high referral rates to the study centers resulting in a relatively large cluster of non-syndromic cases. The geographic location of the study area in the Niger Delta region of Nigeria known for environmental pollution[15-18] from oil exploratory activities and gas flaring over decades cannot be ruled out as a possible confounding contributor.

In the present study, analysis of parental age showed that mothers older than 35 years had more syndromic children with AVCD; possibly due to the underlying higher risk of Down's syndrome babies with increasing maternal age [19]. For the fathers, paternal age above 35 years were more represented amongst non-syndromic children with AVCD. The reason for this is not clearly evident but raises a question into the link between paternal age and non-syndromic AVCD which is beyond the scope of this study. Although the sampled population is small and as such generalization should be done with caution, the study location in the polluted Niger Delta region of Nigeria may have been contributory as have been suggested by other authors in the Niger Delta concerning CHD [11].

The study also showed that children in the sub region with AVCD tended to present late to the hospital in spite of being symptomatic very early. Comparison of the age at onset of symptom and the age at presentation to the hospital shows a significant delay. The reason for this delay was not explored but a lack of screening services for CHD at birth in the region may have been contributory. This is in contrast to findings in developed countries where neonatal screening for CHD exist and most of the affected children have surgical correction of their lesion in infancy [20,21].

Most of the study population had below normal oxygen saturation (SPO_2 <97%) and so the presence of CHD could easily have been detected in the newborn period if they had been screened at birth especially amongst syndromic patients where over half of the patients had moderate to severe reduction in their oxygen saturation. This finding showcases pulse oximetry as a simple and feasible screening tool for CHD in resource poor countries like Nigeria. In addition, early post- natal clinical examination would be beneficial as most of the study population were also symptomatic early.

The commonest clinical features seen were fast breathing, effort intolerance, failure to thrive, cardiac murmurs and cyanosis. These features eventually led to their presentation to the Paediatric Cardiologist after a significant delay from the time of symptom onset. The import of this delay is the development of complications notably pulmonary hypertension especially in children with Down's Syndrome[3,6], as was seen in almost all of the syndromic patients. Pulmonary hypertension (PAH) is a notable contributor to mortality in patients with AVCD and develops early especially in Down's syndrome patients.[3,6] This may well be the case in some of the mortalities observed in this study.

Echocardiographic analysis of the study population revealed that Complete AVCD was the most common type seen in both syndromic and non-syndromic patients, although it was slightly more in the syndromic group. This is similar to reports elsewhere.[3,6,8,9,10] Majority of the study population with the complete type had balanced AVCD similar to other studies where complete isolated balanced AVCD have also been more commonly observed.[2,22] Unbalanced AVCD was seen only in a small proportion of the study population mainly in the non-syndromic category. These few cases of unbalanced AVCD had very complex lesions with various combinations of single ventricle (RV dominance), common atrium, mesocardiac/dextrocardia and TAPVC suggesting heterotaxia. This association of AVCD and heterotaxia has been noted in literature.[3] Partial AVCD was seen more in non-

syndromic patients while the only case with Transitional AVCD had Down's Syndrome.
Additional cardiac anomalies seen in the study population ranged from simple anomalies such as Patent Ductus Arteriosus and pericardial effusion to more complex lesions including Transposition of the Great Arteries (TGA), Double Outlet Right Ventricle (DORV) and Total Anomalous Pulmonary Venous Drainage (TAPVC). Interestingly, most of these complex additional cardiac anomalies were found in the non-syndromic AVCD patients. All but one of the cases of pericardial effusion (PE) seen were in syndromic patients and this is not surprising as PE is a common finding in patients with Down's Syndrome due to possible co-existing hypothyroidism[6,23].

On follow up, only a minority of the study population had corrective surgery done - possibly due to the high cost of surgery in oversea centers in India where the patients went, as facilities for complex congenital heart surgeries are lacking in Nigeria.[13] Of these few who had costly surgeries, two-third were non-syndromic, and only two were syndromic patients, possibly suggesting a prejudice against children with Down's Syndrome who have known mental and other challenges.[6,19,23] Over half of the study population are on oral medication for chronic heart failure while awaiting surgery. This is similar to reports by Ekure et al[13] where a high proportion of CHD patients are only on medical therapy for some symptomatic relieve because they cannot access surgery due to lack of facilities in Nigeria. Oral medications given included Tablet Furosemide (1 to 3 mg/kg/day in two divided doses, 12 hourly) and Tablet spironolactone (1 to 2 mg/kg/day in two divided doses 12 hourly). In those with pulmonary artery hypertension (PAH), Tablet sildenafil is added at 0.5 to 1mg/kg/dose 8 hourly.

A quarter of the study population were lost to follow up. This is quite a high proportion and more so in the subset with Down's Syndrome. The implications of this are varied and may be related to lack of motivation for care for children with Down's syndrome as some parent feel they are not worth the investment amidst scarce resources, due to their developmental and mental delays.[6,19,23,24] Some of the "lost to follow-up" patients may also have died especially those with additional complex lesion as seen in some of the Non-syndromic patients' subsets with TAPVC and TGA. Attempts at contacting the parents of these lost to follow up patients to determine the outcome were unsuccessful due to logistics and communication challenges encountered. Some phone numbers given were no longer in service and addresses could not be traced.

5. CONCLUSION

This study thus concludes that AVCD is more prevalent among non-syndromic patients in the Niger Delta Region of Nigeria. This is worrisome considering the high environmental pollution and degradation in the region.[15-18] Also, additional complex cardiac lesions were more in non-syndromic AVCD patients. Most AVCD patients have reduced SPO2, and there is significant delay in presentation to the Paediatric Cardiologist for evaluation and care.

The recommendation is thus for pulse oximetry screening of newborns for early detection and evaluation; and the establishment of comprehensive paediatric cardiac surgical centers for early and prompt intervention for complex lesions like AVCD. Further studies are required to explore the impact of environmental pollution on risk for non-syndromic AVCD in the region.

6. LIMITATIONS

The study was hospital-based and though it involved the two major Paediatric Cardiology referral centers in Port Harcourt, all children with AVCD in the community may not have been captured.

CONSENT

Informed consent was obtained from the parents of recruited children.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mathews TJ, Arialdi MM, Osterman MJ, Strobino DM, Guyer B. Annual Summary of

Vital Statistics: Pediatrics. 2011;127(1):146-157.

2. Calabrò R, Limongelli G. Complete atrioventricular canal. Orphanet J Rare Dis. 2006;1:8.
Available:https://doi.org/10.1186/1750-1172-1-8
3. Myung KP. Parks Pediatric Cardiology for Practitioners. Myunk KP (Ed) 6th Edition Elsevier Saunders. Philadelphia. 2014;9:05-309.
4. De Angelis F, Savino K, Colombo A, Sardone M, Ambrossio G. Never too grown-up for a congenital heart disease: Diagnosis of transitional atrio-ventricular canal in a 50year-old male. J Cardiovasc Echogr. 2019:29(1):35-28.
5. Pearl JM, Laks H. Intermediate and complete forms of atrioventricular canal. Semin Thorac Cardiovasc Surg. 1997;9:8–20.
6. Chauhan S. Atrioventricular canal defects. Ann Card Anaesth. 2018:21(1):1-3.
7. Squarcia U, Squarcia A. Giancarlo Rastelli: The Scientist, the Man Clin. Cardiol. 2007;30:485 - 487
8. Muntha A, Moges T. Congenital Cardiovascular Anomalies among Cases of Down Syndrome: A Hospital Based Review of Cases in TikurAnbessa Specialized Hospital, Ethiopia. Ethiop J Health Sci. 2019;29(2):165-174
9. Agopian AJ, Moulik M, Gupta-Malhotra M, Marengo LK, Mitchell LE. Descriptive Epidemiology of Non-Syndromic Complete Atrioventricular Canal Defect, Paediatr Perinat Epidiomlo. 2012;26(6):515-24.
DOI:10.1111/ppe.12006.
10. Loffredo CA, Hirata J, Wilson PD, Ferencz C, Lurie IW. Atrioventricular septal defects: possible etiologic differences between complete and partial defects. Teratology. 2001;63:87–93.
11. Otaigbe BE, Tabansi PN. Congenital heart disease in the Niger Delta region of Nigeria: a four-year prospective echocardiographic analysis. Cardiovasc J Afr. 2014;25(6):265-268.
12. Ekure EN. Bode-Thomas F, Sadoh WE, Orogade AA, Otaigbe BE, Ujunwa F, et al. Congenital Heart Defects in Nigerian Children: Preliminary Data from the National Pediatric Cardiac Registry. World Journal for Pediatric and Congenital Heart Surgery. 2017;8(6):699-706.
13. Ekure EN, Sadoh WE, Bode-Thomas F, Yilgwan CS, Orogade AA, Animasahun AB, et al. Audit of availability and distribution of paediatric cardiology services and facilities in Nigeria. Cardiovasc J Afr. 2017;28(1): 54-59.
14. Chinawa JN, Obu HA, Eke CB, Eze JC. Pattern and Clinical Profile of Children With Complex Cardiac Anomaly at University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu State, Nigeria. Niger J Clin Prac. 3013;16(4):462-467
15. Ordinioha B, Brisibe S. The human implication of crude oil spills in the Niger Delta, Nigeria. An interpretation of published studies. Niger Med J. 2013;54(1):10-16.
16. Yakubu O. Particle (ssot) pollution in Port Harcourt Rivers State, Nigeria – Double air pollution burden? Understanding and tackling potential environmental health impacts. Environments. 2018;5; 2.
DOI:10.3390/environments5010002
17. Mckenzie LM, Guo R, Witter RZ, Savitz DA, Newman LS, Adgates JL. Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. Environmental Health Perspective. 2014;122(4):412-417.
18. Nriagu J, Udofia EA, Ekong I, Ebuk G. Health risk associated with oil pollution in the Niger Delta, Nigeria. Int J Environ Res Public health. 2016;1`3;346.
DOI:10.3390//ijeph13030346
19. Towbin JA, Greenberg F. Genetic syndromes and clinical molecular genetics. In: Garson AJ, Bricker JT, Fisher DJ, Neish SR. Eds. The Science and Practice of Pediatric cardiology. 2nd Edition (Volume 11). Williams & Wilkins. Baltimore. 1997;120:2637.
20. Center for Disease Control and prevention (CDC). Newborn screening for congenital heart diseases.
Available:http://www.cdc.gov>ncdbbb>heartdefect>cchd-facts
21. Harold GH. Screening for Critical Congenital Heart Disease in Newborns. Circulation. 2014;130(9).

Available:https://doi.org/10.1161/CIRCULATIONAHA.113.008522
22. Chehab G, El-Rassi I, Abdo A, Fakhoury H, Chokor Imad, Wajdi H, Saliba Z. Atrioventricular septal defect characteristics in infants with and without Down's syndrome: A Lebanes Study. J Med Liban. 2010;58(1):3-7.
23. Pilchard J, Dadlani G, Andropoulos D, Jacobs JP, Cooper DS. Intensive care and perioperative management of patients with complete atrioventricular septal defect. World J Pediatr Congenit Heart Surg. 2010;1:105–11.
24. Edwin AK, Edwin F, McGee SJ. Ethical Dilemmas Relating to the Management of a Newborn with Down Syndrome and Severe Congenital Heart Disease in a Resource-Poor Setting. Narrat Inq Bioeth. 2015;5(3):277-286. DOI10.1353/nib.2015.0060

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/59581