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Findings on the electrocardiogram of children in anaemic heart failure

Odike AI[1], Omokhodion SI[2], Akpede GO[1]

1. Department of Paediatrics, Irrua Specialist Teaching Hospital, Edo, Nigeria
2. Department of Paediatrics *University College Hospital, Ibadan, Nigeria

Abstract

Background: Heart failure is a common complication of anaemia in children. It is also an important cause of mortality in these children. Electrocardiography was used to study the heart of children presenting in Irrua Specialist Teaching Hospital in anaemic heart failure.

Subject and Method: Consecutive patients with anaemia were recruited from the Paediatric Unit of Irrua Specialist Teaching Hospital (ISTH), Irrua, Edo state, Nigeria between September and December 2009. Ninety four children (cases) aged 6 months to 16 years with anaemia (packed cell volume (PCV) <33%) and 94 age and sex- matched controls without anaemia (PCV ≥33%) were examined. Eleven patients (11.7% of the 94 anaemic cases) were in anaemic heart failure. Each case and control was assessed clinically following which the cardiovascular function was evaluated using electrocardiography. Data was analysed using the appropriate statistical test. P-values less than 0.05 were taken as indicative of statistical significance.

Results: A total of 188 children were evaluated. Eleven patients were in anaemic heart failure. The prevalence of ECG abnormalities was 100% in the cases with anaemic heart failure as against 40.4% in the controls. This was statistically significant (p<0.0001). There was a statistically significant number of cases with sinus tachycardia (p=0.0001). Other abnormalities recorded were LVH, RVH, LQTc, ST segment depression and rSR conduction pattern.

Conclusions: The major effect caused by anaemic heart failure on the heart of children is sinus tachycardia.

Keywords: Anaemia, Heart failure, Electrocardiographic changes, Left ventricular hypertrophy (LVH)

Introduction

Housing is one of the most important basic necessities of mankind and it is known to tremendously affect human health and well-being.[1] It is widely acknowledged that adequate housing is essential for good life, is a key requirement for an efficient and satisfied labour force and the foundation of satisfactory community life.[2]

Materials and Methods

The study was a prospective study of the ECG changes in 188 children between the ages of 6 months and 16 years seen in the Paediatric Department of ISTH over a three month period. Anaemia in this study was defined as PCV <33%. [3,4,18] The cases with anaemia were 94 in number and the controls were 94 and had PCV of 33% and above. The subjects were categorized into 5 groups in line with standard practice : 6-<12 months, 12-<36 months, 36-<96 months, 96-<144 months and 144-<192 months.[19] The anaemic cases were further classified into sickle cell anaemia subjects (SCA) or non-SCA subjects based on their genotype and patients in anaemic heart failure (AHF) or not in AHF. Anaemia was classified as mild, moderate or severe . Mild anaemia was defined as haematocrit of less than 33% but greater than or equal to 30%, moderate anaemia as haematocrit of less than 30% but greater than or equal to 21% and severe anaemia as haematocrit of less than 21%.[20]

Children with diagnosed or suspected congenital or acquired heart disease, renal impairment , diarrhoeal disease and children on cardiovascular acting drugs like antihypertensives and β-agonists were disqualified from the study.

Corresponding Author: **Dr A.I .Odike**
Departments of Paediatrics,
Irrua Specialist Teaching Hospital (ISTH), Edo State, Nigeria
E-mail address: angelaodike@gmail.com

The weight, height, pulse rate, and blood pressure of each child was taken using standard equipments. Blood samples were collected for genotype and PCV check. A resting period of not less than 30 minutes was given to calm each child before an ECG was performed. This was to ensure that the values obtained are truly representative of their resting state.

The ECG was recorded with a portable commercially available BTL-08 SD ,3 channel machine with a sampling frequency of 1000 Hz. The ECG parameters were read from the ECG tracing and the normal references were from Myung Park's "How to read Paediatric ECGs"[19] unless otherwise stated . The parameters checked were rhythm, rate, frontal plane axis of the QRS and T waves, QRS-T angle , PR, QRS complex duration, QT interval, QTc, P wave duration and amplitude, ST elevation or depression and T wave amplitude and duration.

The data was analysed using Microsoft Excel programme 2002 and Statistical Package for Social Sciences (SPSS) version 16. Means and standard deviations of various ECG variables were determined. Independent Student's t test was used to compare the means of ECG variables between cases and controls. Analysis of variance was used to analyse more than two sample means and chi-squre test was used for the analysis of discrete data. P-value <0.05 was considered to be statistically significant.

Results

A total of 188 children were recruited for the study comprising 94 cases who were anaemic with PCV < 33% and 94 controls who were not anaemic with PCV ≥ 33%. The ages of the children ranged from 6 months to 16 years . Eleven (11.7%) cases (52.4% of those with severe anaemia) were in anaemic heart failure. Table I shows the distribution of the severity of anaemia among the cases.

Table I. Distribution of the severity of anaemia among the cases

Variables	Severity of anaemia		
	Mild	Moderate	Severe
No of cases (%)	30 (31.9)	43(45.7)	21(22.3)
Mean (±SD) PCV	31.1(0.88)	25.2(2.43)	16.6(4.3)

A Table II: Age group, sex distribution and genotype of cases in AHF

Age group	Non-SCA		SCA		Total
	Male	**Female**	**Male**	**Female**	
6- < 12	**0**	**1**	**0**	**0**	**1**
12- < 36	**0**	**4**	**0**	**0**	**4**
36- < 96	**3**	**0**	**2**	**0**	**5**
96- < 144	**0**	**0**	**0**	**0**	**0**
144 -< 192	**0**	**0**	**1**	**0**	**1**
Total	**3**	**5**	**3**	**0**	**11**

Table III: ECG parameters in the non-SCA female cases in AHF and controls in the 12-<36 months age group

Parameters	Non-SCA , AHF n = 4 Mean ± SD (range)	Controls n =3 Mean ± SD (range)	t-value	p-value
Heart rate	179.3 ± 15.5 (150-187)	93.3 ± 5 (90-100)	8.9	0.00
QRS axis (degrees)	37.5 ± 28.7 (0-60)	0.0 ± 17.3 (-30-0)	2.5	0.05
T axis (degrees)	37.5 ± 28.7 (0-60)	30 ± 0.0 (30)	0.4	0.68
QRS-T angle (degrees)	15 ± 17.3 (0-30)	40 ± 17.3 (30-60)	-1.9	0.12
P amplitude (mm)	0.85 ± 0.45 (0.5-1.5)	1.6 ± 0.04 (1.1-1.8)	-2.2	0.08
P duration (seconds)	0.06 ± 0.02 (0.04-0.08)	0.06 ± 0.03 (0.04-0.08)	-0.2	0.87
PR interval (seconds)	0.11 ± 0.01 (0.1-0.12)	0.13 ± 0.03 (0.1-0.16)	-1.4	0.23
QRS duration (seconds)	0.05 ± 0.01 (0.04-0.08)	0.06 ± 0.03 (0.03-0.08)	0.7	0.52
QT interval (seconds)	0.22 ± 0.01 (0.22-0.24)	0.32 ± 0.0 (0.32)	-16.1	0.00
QTc	0.39 ± 0.02 (0.36-0.42)	0.43 ± 0.1 (0.4-0.5)	-1.4	0.23
R amplitude in V1 (mm)	7.5 ± 3.7 (3-11)	4.7 ± 1.2 (4-6)	1.3	0.27
R amplitude in V6 (mm)	12 ± 2.8 (8-14)	14.7 ± 2.3 (12-16)	-1.3	0.24
R/S ratio in V1	2.03 ± 2.7(0.3-6)	0.8 ± 0.2 (0.7-1)	0.8	0.48
R/S ratio in V6	10.25 ± 3.3 (8-14)	7.3 ± 1.2 (6-8)	1.4	0.21

Three of the 11 cases (27.3%) had SCA while 8 (72.7%) were non-SCA cases. All the eight without SCA had haemoglobin genotype AA (HbAA). The mean PCV in

Parameters	Non-SCA M=3 Mean ± SD (range)	SCA M=2 Mean ± SD (range)	Controls M=17 Mean ± SD (range)	F	p-value
Heart rate	131.7 ± 13.3 (126-150)	130.5 ± 7.7 (125-136)	102.9 ± 23.9 (55-150)	1.1	0.35
QRS axis (degrees)	60 ± 0.0 (60)	15 ± 63.6 (-30-60)	58.2 ± 22.4 (0-90)	2.7	0.09
T axis (degrees)	50 ± 17.3 (30-60)	45 ± 21.2 (30-60)	44.1 ± 15.4 (30-90)	0.2	0.84
QRS-T angle (degrees)	10 ± 17.3 (0-30)	30 ± 42.4 (0-60)	19.4 ± 23.6 (0-60)	0.4	0.67
P amplitude (mm)	1.5 ± 0.76 (0.6-2)	1.5 ± 0.7 (1-2)	1.5 ± 0.5 (0.8-2)	0.002	0.98
P duration (seconds)	0.06 ± 0.02 (0.05-0.08)	0.06 ± 0.02 (0.04-0.08)	0.07 ± 0.01 (0.05-0.1)	0.9	0.39
PR interval (seconds)	0.13 ± 0.02 (0.12-0.16)	0.13 ± 0.01 (0.12-0.14)	0.14 ± 0.02 (0.11-0.17)	0.1	0.87
QRS duration (seconds)	0.07 ± 0.01 (0.06-0.08)	0.05 ± 0.01 (0.05-0.06)	0.06 ± 0.01 (0.03-0.08)	2.04	0.16
QT interval (seconds)	0.33 ± 0.3 (0.3-0.36)	0.28 ± 0.0 (0.28)	0.3 ± 0.03 (0.22-0.36)	1.2	0.33
QTc	0.42 ±0.02 (0.4-0.44)	0.41 ± 0.01 (0.4-0.42)	0.40 ± 0.03 (0.35-0.48)	0.3	0.76
R amplitude in V1 (mm)	8.6 ± 1.2 (8-10)	11 ± 4.2 (8-14)	7.5 ± 3.4 (1-12)	1.1	0.35
R amplitude in V6 (mm)	18.3 ± 10.2 (11-30)	17 ±4.2 (14-20)	13.9 ± 5.5 (8-32)	0.8	0.46
R/S ratio in V1	0.73 ±0.51 (0.3-1.3)	0.9 ± 0.3 (0.7-1.1)	0.61 ±0.4 (0.1-1.8)	0.5	0.61
R/S ratio in V6	18.3 ± 10.2 (11-30)	17 ± 4.2 (14-20)	12.2 ± 6.8 (3.5-32)	1.2	0.32

the SCA cases was 10.3±6.8% and the mean in the non-SCA was 16.7± 4.9 %. The difference was not statistically significant (t = -1.76, p = 0.11). Table II shows the age groups, sex and genotype of the cases in anaemic heart failure.

Analysis of the ECG changes in the anaemic heart failure (AHF) cases was not possible among all the age groups and sexes due to too few or absence of cases in these groups. Analysis of the ECG of the non-SCA females in AHF in the 12- <36 age group is shown on Table III. There was a statistically higher mean heart rate in the non-SCA cases than the controls (t = 8.9, p = 0.000) and a statistically lower mean QT interval in the non-SCA cases than the controls (t = -16.1, p = 0.000).

Table IV: ECG parameters in the non-SCA and SCA male cases in AHF and controls in the 36- < 96 months age group

Table IV shows the ECG parameters in the non-SCA and SCA male cases in AHF in the 36-<96 months age group compared with the controls. There were no statistically significant differences in the mean values of all the ECG parameters in the three groups of subject but the mean heart rate, QTc, RV1, RV6, R/SV1 and R/SV6 were higher in the cases than in the controls.

The prevalence of ECG abnormalities in the non-SCA and SCA cases in heart failure was 11/11 (100%). The relationship between the presence of heart failure and the prevalence of ECG abnormalities in the cases is further illustrated in figure 1.

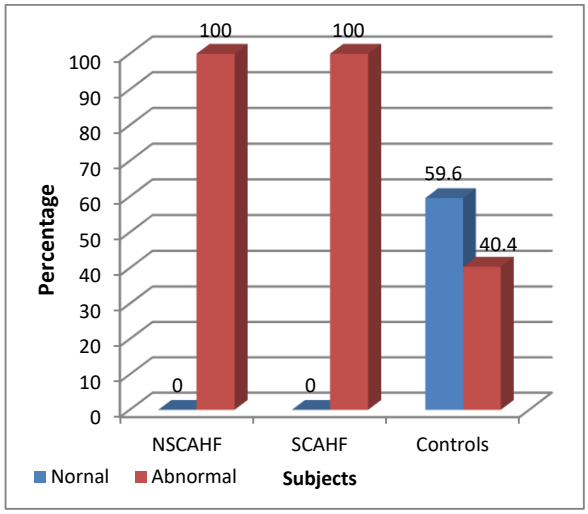

Figure 1: Frequency of ECG abnormalities in cases in anaemic heart failure and controls
NSCAHF = Non-SCA in heart failure, SCAHF = SCA in heart failure

The frequency of individual abnormalities in the AHF cases is shown on Table V.

Table V: The ECG abnormalities in Cases in AHF and controls.

ECG abnormalities	Non-SCA n=8 (%)	SCA cases n=3 (%)	Controls n=94 (%)	X^2	*p*-value
Sinus tachycardia	**8(100)**	**3 (100)**	**13(13.8)**	**NA**	**NA**
LVH	**2(25)**	**2 (66.7)**	**21(22.3)**	**NA**	**NA**
RVH	**1(12.5)**	**0 (0)**	**4(4.3)**	**NA**	**NA**
Long QTc	**1(12.5)**	**1 (33.3)**	**7(7.4)**	**NA**	**NA**
ST segment depression	**0(0)**	**1(33.3)**	**0(0)**	**NA**	**NA**
rSR pattern	**0(0)**	**1 (33.3)**	**3(3.2)**	**NA**	**NA**

LVH = Left ventricular hypertrophy, RVH = Right ventricular hypertrophy, n=number of subjects

Discussion

Anaemic heart failure is a common complication of anaemia in children in developing countries [16,17] The eletrocardiographic findings in anaemic heart failure were documented in this study.

Eight of the non-SCA cases and 3 of the SCA cases were in heart failure and the abnormalities seen in these cases were compared with the controls. There was a dearth of literature with which to compare the findings in AHF. All (100%) the non-SCA and SCA cases in AHF had ECG abnormalities. The major abnormality in the AHF cases was sinus tachycardia which occurred in 100% of them . The higher prevalence of sinus tachycardia in the cases is similar to the finding by Feiner *et al*[21] and Van der Linden[22] but the cases in their study were not in anaemic heart failure.

Increased heart rate in anaemia is one of the compensatory mechanisms to increase oxygen supply to the vital organs like the brain and the heart.[12] Myocardial ischemia resulting from imbalance between myocardial oxygen supply and demand may also be a contributory factor to the observed increased heart rate. [12,23] The heart is a flow dependent organ, so , coronary blood flow must be increased to increase oxygen delivery to the heart[12,23] as there is increased oxygen consumption in anaemia both at rest and during exercise.[24] The SCA cases in AHF had a higher prevalence of all the ECG abnormalities found in AHF. This may be due to the chronic anaemia which may have caused these changes prior to the heart failure. These abnormalities are in agreement with the hyperdynamic syndrome , pulmonary congestion and volume overload that is associated with AHF[25] and also the presence of myocardial infarction.

The study also showed that the SCA cases in AHF had a lower mean PCV (10.3 ±6.8%) than the non-SCA cases in AHF (16.7 ±4.9%) . SCA is a chronic anaemic state. The heart of the cases must have adapted over a long period to the anaemic state and therefore would require a lower PCV to go into failure than patients with acute anaemic states. The PR interval was shorter and mean heart rate faster in non-SCA AHF cases.

A total of 3 (37.5%) of the non-SCA, AHF and 2(66.7%) SCA , AHF cases had ventricular hypertrophy. These findings are similar to the findings by previous workers[10,26] in patients with anaemia. In anemia there is increased sympathetic activity and vasodilation which results in increased cardiac output, heart rate and contractility and leads to volume mediated ventricular dilatation.

ST segment depression is an indicator of myocardial ischemia and usually occurs when coronary blood flow can no longer match myocardial oxygen demand.[22] Anaemia is the commonest non coronary cause of ST segment depression.[27] In the present study only one case had ST segment depression. This case was critically ill. He also had right ventricular hypertrophy, and had a PCV of 5% .

The rSR' conduction pattern seen in one SCA case maybe an indication of ventricular hypertrophy or conduction disturbance. [28] The QRS duration were within normal limits in this case and this is in keeping with the normal variants. [28]

One patient each in the SCA (33.3%) and non-SCA (12.5%) had long QTc. Prolongation of the QTc, which can be due to myocardial ischaemia,[29] indicates abnormal repolarization, which may predispose to ventricular arrhythmia and sudden death.[30]

Conclusion

Anaemic heart failure causes ECG changes which include Long QTc, LVH, RVH and ST segment depression but sinus tachycardia is the main effect of anaemic heart failure on the ECG in children.

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