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The Evaluation of Electrocardiography Parameters Changes in Breath-Holding Children Compared to Controls

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Abstract

Background

Breath-holding spells (BHS) are brief periods when young children stop breathing for up to 1 minute and are widely recognized types of non-epileptic severe occasions in early stages of childhood. This study aimed to evaluate QTd and QTc changes in children with breath-holding spells compared with healthy children.

Materials and Methods

This case-control study was conducted to evaluate ECG parameters' changes in 90 children with breath-holding spells compared to 90 healthy children, who were included as controls, without any breath - holding in pediatric neurology clinic of Ali Asghar Hospital of Medical Sciences, University of Zahedan (ZaUMS), Iran, in 2018. Electrocardiography measures were measured from 12-lead surface electrocardiograms of the patients and the control group. Data were analyzed using SPSS software version 18.0.

Results

In the study there were 46 (51.1%), and 35(38.9%) females in controls and Breath Holding patients, respectively. QT max ($p=0.002$), S in V1 ($P<0.001$), R in V5 ($p<0.001$), R in aVL ($p<0.001$), S in V3 ($p=0.002$), LV mass ($p<0.001$), QTd ($p<0.001$), QTc max ($p<0.001$), and QTcd ($p<0.001$) were different in patients compared to controls, significantly ($p<0.05$). QTd ($p<0.001$), QTc max ($p=0.03$), and QTcd ($p<0.001$) were higher in pallid attacks, significantly. QT max ($p=0.039$), and QT min ($p=0.039$) were different in boys and girls so that QT max and QT min were higher in girls.

Conclusion

From the present study it can be concluded that QT, QTc, QTd and QTcd were higher in BHS. QTd, QTc max and QTcd were higher in pallid and QT max and QT min were higher in girls. However, in spite of what is reported in some studies, we suggest that obtaining ECG parameters is necessary to assess rhythm abnormality in children with BHS.

Key Words: Breath-Holding, Children, Electrocardiography.

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1- INTRODUCTION

Breath-holding spells (BHS) are a well described phenomenon known to occur mostly among children 6 to 18 months of age. Some reports agree with its occurrence up to 4 years of age (1, 2). Almost 5% of the pediatric population might experience this event. BHS are described as infants crying for up to a minute, and while crying excessively they will hold their breath to a point at which they might lose consciousness, so it may be extremely frightening to parents. It has been reported that BHS are not harmful and pose no long-term risks for the infant (2). On rare occasions a seizure might be witnessed immediately after the infant loses consciousness; soon thereafter, the infant will usually regain consciousness and breathe normally. In 90% of children BHS are resolved by school age and the persistence is extremely rare. There are two types of cyanotic and pallid BHS. Some children have both types at some time of their lives (3). The mechanism of BHS remains controversial. The presence of autonomic imbalance with cerebral anoxia, anemia and genetic disorders may be responsible in these spells (3, 4).

Despite the uncommon difficulties in BHS, sudden death, prolonged asystole, and status epilepticus have been reported. A detailed history and examination are important to successfully diagnose BHs and help distinguish it from epileptic seizures and other causes of syncope (3). An uncommon events seizure may be seen following a baby losing consciousness; soon after, the newborn child will, as a rule, recapture cognizance and inhale regularly. The autonomic irregularity with cerebral anoxia, iron deficiency and the hereditary issue might be responsible for these spells (4, 5). Nevertheless, among most of the studies directed regarding BHS, autonomic dysregulation has been proposed to have a significant role in its pathophysiology (6).

Prolonged electrocardiography (ECG) parameters such as QT dispersion (QTd), and QT correction (QTc) demonstrate an extended risk of dysrhythmia, mitral valve prolapses, ischemic coronary disease and renal dissatisfaction (6). ECG parameters are straightforward strategies, which are useful for non-intrusive evaluation of the heterogeneity of repolarization inside the ventricular myocardium utilizing the surface electrocardiogram.

ECG parameters are factors that have been evaluated as a predictor of mortality in various diseases (7), including diabetes mellitus (8), celiac (9), thalassemia (10), epilepsy (11) breath holding (6) and febrile seizure (12). Cardiovascular alterations associated with breath holding (4), are generally considered to reflect autonomic nervous system activation. In the other side, ECG parameters changes occur transiently in the general population, for example, consequent to medications, electrolyte abnormalities, or endocrine disease (13). Considering the above-mentioned facts, the present study aimed to evaluate ECG findings changes in children with breath-holding spells compared with healthy ones.

2- MATERIALS AND METHODS

2-1. Study design and population

This case-control study was conducted to evaluate ECG parameters' changes in the children with breath-holding spells compared to healthy ones in 2018. The patients were 90 individuals. Sample size for the study was estimated using the following formulae by the parameters issued from Akalin et al.'s study (6).

$$n= (Z_\alpha +Z_\beta)^2(\sigma_1^2+ \sigma_2^2)/(\mu_1-\mu_2)^2$$

Where, $^{Z}{}_{\alpha}$=1.96, Z_β=0.85, σ_{case}=29.7, $\sigma_{control}$=23.8, μ_{case}=299.1, $\mu_{control}$=287.8, n= 89.57 that considered 90 individuals in each group.

Participants were selected randomly from those who were referred to the pediatric neurology clinic of Ali Asghar Hospital of Medical Sciences University of Zahedan (ZaUMS), Iran, due to cyanotic attacks and/or fainting and who were diagnosed to have breath-holding spells by observation of the typical attacks during an examination or by obtaining the typical history. Healthy individuals were similar in frequency and selected randomly from those who were referred to the clinics for the routine checkup.

2-2. Ethical Approval

Consent form was obtained from the participants or their guardians after the study approval. The study was approved as a resident thesis (ID-code: 945) by the Ethics Committee of Zahedan University of Medical Sciences, Zahedan, Iran.

2-3. Exclusion Criteria

Diagnosis of severe BHS was based on the history of BHS taken from the parents (three or more spells in 1 month) before entry into the study protocol, defined by the following clinical sequence: provocation followed by crying to a point of losing consciousness. BHS classified in two groups of pallid and cyanotic based on the skin color change during episodes; and ultimately a loss of consciousness with an associated alteration in body tone (4). Both a pediatric cardiologist and a pediatric neurologist had evaluated the patients, and any cardiac or neurological disease was excluded. Children with the diagnosis of epilepsy, electrolyte disturbance, hypoglycemia, Iron deficiency, impaired kidney function, those with abnormal neurological findings during examination, those who received or were receiving any medications for BHS, or those with a doubtful diagnosis were also excluded from the study.

2-4. Electrocardiography measures

Electrocardiogram (ECG) was detected with an electrocardiogram by Sa'adat device made in Iran initially from 30 minutes to 2 hours after seizure. ECG in standard scheme was obtained once the patients or controls had rested for 10 minutes in a supine position in a quiet room. All 12-ECG leads were simultaneously recorded at a paper speed of 25 mm/s and a voltage of 10 mm/mV. A single experienced person made the following measurements. To evaluate intra-observer variations, the same person measured the same ECG leads on two separate occasions. QT interval was accepted as the distance from the beginning of the Q wave to the end of the T wave. In each lead, the duration from the beginning of the Q wave to the end of the T wave was calculated in milliseconds and the average was taken (QT average) for three consecutive beats. The maximum and minimum duration of the QT wave was selected from the 12 leads of the surface ECG. The difference between maximum and minimum duration was defined as QTd. The average QTc was calculated using the same QT interval measured using the Bazett formula ($QTc = QT/\sqrt{RR}$); among all derivations, the difference between the longest and shortest QTc was calculated (QTcd) (10). To calculate left ventricular mass in ECG we used the following formulas. LV mass (g) $=0{\cdot}026(RaVL+SV3)+1{\cdot}25Weight+34{\cdot}4$ for boys, and $0{\cdot}020(RaVL+SV3)+1{\cdot}12Weight+36{\cdot}2$ for girls (14).

2-5. Statistical Analysis

Data were analyzed using SPSS software version 20.0 (IBM Corp. Released 2011. The Kolmogorov-Smirnov test was used to evaluate the distribution of data. For the qualitative variables, frequency and percentage indices were used, and Chi-squared test was applied for the probable association between two variables. For the quantitative variables, mean and standard deviation was used with Mann-Whitney U-

test for investigating the difference between variables. The level of 0.05 was considered significant.

3- RESULTS

Mean age of the participants was 2.25±1.13 in the range of 0.42-7.00y. Mean age of breath-holding was 2.19±1.37y lower than 2.30±0.82y as mean age for controls. This slight variation in age showed similarity (p=0.487). The study analyzed changes in ECG parameters in the children with BHS and healthy ones. The normality test showed that all ECG parameters had free distribution in all participants and patients (**Table.1**). **Table.2** showed that there were 46(51.1%), and 35(38.9%) females in controls and in patients respectively; the sex distribution in groups of participants was similar (X^2=2.176, p=0. 099).

Table-1: Testing Data distribution based on normality using Kolmogorov–Smirnov test for all participants and patients.

Breath Holding patients					Breath Holding patients and controls			
Variables	Mean	SD	KS	P value	Mean	SD	KS	P value
Weight	10.3867	3.22404	0.113	0.006	12.5372	6.94497	0.198	0.000
Height	82.6889	10.85827	0.111	0.008	88.2833	14.34960	0.068	0.041
QT min	0.2921	0.03052	0.201	0.000	0.2907	0.03285	0.172	0.000
QT max	0.3261	0.03129	0.211	0.000	0.3187	0.03300	0.188	0.000
R-R interval	0.5714	0.09046	0.109	0.010	0.5704	0.10169	0.120	0.000
Heart Rate	108.7444	19.27481	0.119	0.003	108.7611	22.82686	0.112	0.000
S in V1	0.3739	0.22426	0.218	0.000	0.5481	0.34538	0.139	0.000
R in V5	0.7850	0.33060	0.160	0.000	0.9036	0.40150	0.124	0.000
R in aVL	0.4351	0.21890	0.150	0.000	0.3351	0.21441	0.180	0.000
S in V3	0.4967	0.32062	0.163	0.000	0.5706	0.35228	0.150	0.000
LVM	47.3455	6.19338	0.202	0.000	50.0999	9.24415	0.195	0.000
QTd	0.0340	0.01347	0.294	0.000	0.0280	0.01380	0.247	0.000
QTcmax	0.4336	0.03461	0.084	0.146	0.4232	0.03339	0.062	0.086
QTcmin	0.3878	0.02805	0.149	0.000	0.3858	0.02846	0.096	0.000
QTcd	0.0458	0.01968	0.155	0.000	0.0376	0.01952	0.156	0.000

K.S.: Kolmogorov–Smirnov. RR: R-R interval. HR: Heart Rate. QT: a measure of the time between the start of the Q wave and the end of the T wave in the heart's electrical cycle. QTc: QT/√ RR. QTd: QT max-QT min. QTcd: QTc max-QTc min. R in v5: The amplitude of R wave in the left Precordial lead. S in v1: The amplitude of S wave in the right Precordial lead. R in aVL: The amplitude of R wave in the left Hand lead. S in V5: the amplitude of S wave in the left Precordial lead. LVM: Left Ventricular Mass.

Table-2: The Distribution of the Breath holding patients and control groups regarding gender.

Gender	Statistics	Group		Total	Chi-Square	P-value
		Control	Breath Holding			
Female	Number	46	35	81	2.716	0.099
	%	51.1%	38.9%	45.0%		
Male	Number	44	55	99		
	%	48.9%	61.1%	55.0%		
Total	Number	90	90	180		
	%	100.0%	100.0%	100.0%		

Table.3 showed weight, height, and ECG parameters values in case and controls. The **Table.3** revealed that weight and height were higher in controls, significantly ($p<0.001$). Among the ECG parameters, QT max ($p=0.002$), S in V_1 ($p<0.001$), R in V_5 ($p<0.001$), R in aVL ($p<0.001$), S in V_3 ($p=0.002$), LV mass ($p<0.001$), QTd ($p<0.001$), QTc max ($p<0.001$) and QTcd ($p<0.001$) were different in patients compared to controls, significantly. The difference in these variables considering higher values in patients consisted of QT max, R in aVL, QTd, QTc max and QTcd. For the other parameters, controls had higher levels.

Table-3: Mean of LV mass, Weight, Height and ECG parameters in the Breath holding patients and control.

Variables	Group	Mean	SD	Mean Rank	Sum of Ranks	MW u	P-value
Weight	Control	14.69	8.79	115.43	10389.00	1806.00	<0.001
	BH	10.39	3.22	65.57	5901.00		
Height	Control	93.88	15.26	112.64	10137.50	2057.50	<0.001
	BH	82.69	10.86	68.36	6152.50		
QT min	Control	0.29	0.04	88.19	7937.50	3842.50	0.541
	BH	0.29	0.03	92.81	8352.50		
QT max	Control	0.31	0.03	78.47	7062.00	2967.00	0.002
	BH	0.33	0.03	102.53	9228.00		
R-R interval	Control	0.57	0.11	90.79	8171.00	4024.00	0.94
	BH	0.57	0.09	90.21	8119.00		
Heart Rate	Control	108.78	26.01	89.81	8082.50	3987.50	0.857
	BH	108.74	19.27	91.19	8207.50		
S in V1	Control	0.72	0.36	117.36	10562.50	1632.50	<0.001
	BH	0.37	0.22	63.64	5727.50		
R in V5	Control	1.02	0.43	105.57	9501.00	2694.00	<0.001
	BH	0.79	0.33	75.43	6789.00		
R in aVL	Control	0.24	0.16	64.12	5770.50	1675.50	<0.001
	BH	0.44	0.22	116.88	10519.50		
S in V3	Control	0.64	0.37	102.24	9201.50	2993.50	0.002
	BH	0.50	0.32	78.76	7088.50		
LVM	Control	52.85	10.87	114.97	10347.50	1847.50	<0.001
	BH	47.35	6.19	66.03	5942.50		
QTd	Control	0.02	0.01	67.16	6044.00	1949.00	<0.001
	BH	0.03	0.01	113.84	10246.00		
QTc max	Control	0.41	0.03	75.08	6757.00	2662.00	<0.001
	BH	0.43	0.03	105.92	9533.00		
QTcmin	Control	0.38	0.03	89.12	8020.50	3925.50	0.721
	BH	0.39	0.03	91.88	8269.50		
QTcd	Control	0.03	0.02	68.00	6120.00	2025.00	<0.001
	BH	0.05	0.02	113.00	10170.00		

M WU: Mann-Whitney U, R-R: R-R interval. HR: Heart Rate. QT: a measure of the time between the start of the Q wave and the end of the T wave in the heart's electrical cycle. QTc: QT/√ RR. QTd: QT max-QT min. QTcd: QTc max-QTc min. R in v5: The amplitude of R wave in the left Precordial lead. S in v1: The amplitude of S wave in the right Precordial lead. R in aVL: The amplitude of R wave in the left Hand lead. S in V5: the amplitude of S wave in the left Precordial lead. LVM: Left Ventricular Mass.

Table.4 showed weight, height, and ECG parameters values in pallid and cyanotic groups of patients. **Table.4** revealed that among the variables in the study, QTd ($p<0.001$), QTc max ($p=0.03$) and QTcd ($p<0.001$) were significantly higher in pallid. Weight, height and ECG parameters were compared in patients based on gender grouping. **Table.5** reported that only height ($p=0.009$), QT max ($p=0.039$), and QT min ($p=0.039$) were different in boys and girls so that QT max and QT min were higher in girls when boys had more height.

Table-4: Mean of LV mass, Weight, Height and ECG parameters in the Breath holding patients' groups of Pallid and Cyanotic.

Variables	Groups of Patients	Mean	SD	Mean Rank	Sum of Ranks	MWU	P- value
Weight	Cyanotic	10.26	3.12	44.81	3808.50	153.50	0.297
	Pallid	12.52	4.59	57.30	286.50		
Height	Cyanotic	82.69	10.95	45.52	3869.50	210.50	0.972
	Pallid	82.60	10.21	45.10	225.50		
QT min	Cyanotic	0.29	0.03	46.65	3965.00	115.00	0.074
	Pallid	0.27	0.02	26.00	130.00		
QT max	Cyanotic	0.33	0.03	45.13	3836.00	181.00	0.571
	Pallid	0.33	0.01	51.80	259.00		
R-R interval	Cyanotic	0.58	0.09	46.58	3959.00	121.00	0.103
	Pallid	0.50	0.12	27.20	136.00		
Heart Rate	Cyanotic	109.40	19.34	46.35	3940.00	140.00	0.198
	Pallid	97.60	15.69	31.00	155.00		
S in V1	Cyanotic	0.37	0.22	45.19	3841.50	186.50	0.642
	Pallid	0.42	0.28	50.70	253.50		
R in V5	Cyanotic	0.77	0.32	44.96	3822.00	167.00	0.419
	Pallid	0.98	0.48	54.60	273.00		
R in aVL	Cyanotic	0.43	0.22	45.31	3851.00	196.00	0.769
	Pallid	0.46	0.23	48.80	244.00		
S in V3	Cyanotic	0.51	0.32	46.56	3957.50	122.50	0.11
	Pallid	0.30	0.23	27.50	137.50		
LVM	Cyanotic	47.16	6.21	44.79	3807.00	152.00	0.287
	Pallid	50.45	5.61	57.60	288.00		
QTd	Cyanotic	0.03	0.01	43.04	3658.00	3.00	<0.001
	Pallid	0.06	0.01	87.40	437.00		
QTc max	Cyanotic	0.43	0.03	44.05	3744.50	89.50	0.03
	Pallid	0.47	0.04	70.10	350.50		
QTc min	Cyanotic	0.39	0.03	45.39	3858.00	203.00	0.867
	Pallid	0.39	0.04	47.40	237.00		
QTcd	Cyanotic	0.04	0.02	43.02	3657.00	2.00	<0.001
	Pallid	0.09	0.02	87.60	438.00		

M WU: Mann-Whitney U, R-R: R-R interval. HR: Heart Rate. QT: a measure of the time between the start of the Q wave and the end of the T wave in the heart's electrical cycle. QTc: QT/√ RR. QTd: QT max-QT min. QTcd: QTc max-QTc min. R in v5: The amplitude of R wave in the left Precordial lead. S in v1: The amplitude of S wave in the right Precordial lead. R in aVL: The amplitude of R wave in the left Hand lead. S in V5: the amplitude of S wave in the left Precordial lead. LVM: Left Ventricular Mass.

Table-5: Mean of LV mass, Weight, Height and ECG parameters in the groups of Breath holding patients.

Variables	Gender	Number	Mean	SD	Mean Rank	Sum of Ranks	MWU	P value
Weight	Females	35	10.1543	3.36280	41.37	1448	818	0.23
	Males	55	10.5345	3.15502	48.13	2647		
Height	Females	35	78.8571	9.58597	36.5	1277.5	647.5	0.009
	Males	55	85.1273	10.99504	51.23	2817.5		
QT min	Females	35	0.3006	0.02678	52.33	1831.5	723.5	0.039
	Males	55	0.2867	0.03174	41.15	2263.5		
QT max	Females	35	0.3340	0.02614	52.5	1837.5	717.5	0.039
	Males	55	0.3211	0.03343	41.05	2257.5		
R-R interval	Females	35	0.5883	0.09703	50.41	1764.5	790.5	0.15
	Males	55	0.5607	0.08520	42.37	2330.5		
Heart Rate	Females	35	111.5714	20.22271	48.94	1713	842	0.315
	Males	55	106.9455	18.61045	43.31	2382		
S in V1	Females	35	0.3357	0.20707	40.71	1425	795	0.16
	Males	55	0.3982	0.23313	48.55	2670		
R in V5	Females	35	0.8014	0.34821	46.89	1641	914	0.685
	Males	55	0.7745	0.32172	44.62	2454		
R in aVL	Females	35	0.3871	0.20268	39.97	1399	769	0.105
	Males	55	0.4656	0.22510	49.02	2696		
S in V3	Females	35	0.5029	0.24191	47.74	1671	884	0.512
	Males	55	0.4927	0.36406	44.07	2424		
LVM	Females	35	47.5906	3.76708	43.09	1508	878	0.484
	Males	55	47.1895	7.36349	47.04	2587		
QTd	Females	35	0.0334	0.01110	43.71	1530	900	0.569
	Males	55	0.0344	0.01488	46.64	2565		
QTc max	Females	35	0.4384	0.03228	47.03	1646	909	0.658
	Males	55	0.4305	0.03597	44.53	2449		
QTc min	Females	35	0.3940	0.02577	51.07	1787.5	767.5	0.106
	Males	55	0.3839	0.02895	41.95	2307.5		
QTcd	Females	35	0.0444	0.01614	43.37	1518	888	0.536
	Males	55	0.0466	0.02174	46.85	2577		

M WU: Mann-Whitney U, R-R: R-R interval, HR: Heart Rate, QT: a measure of the time between the start of the Q wave and the end of the T wave in the heart's electrical cycle,QTc: QT/√ RR,QTd: QT max-QT min, QTcd: QTc max-QTc min, R in V5: The amplitude of R wave in the left Precordial lead. S in V1: The amplitude of S wave in the right Precordial lead. R in aVL: The amplitude of R wave in the left Hand lead. S in V5: the amplitude of S wave in the left Precordial lead. LVM: Left Ventricular Mass.

4- DISCUSSION

The study aimed to analyze the ECG parameters in children with breath-holding spells. The study results showed that BHS patients had higher values in QT max, R in aVL, QTd, QTc max and QTcd compared with controls. For the other parameters such as LV Mass, controls had higher levels. In the BHS patients, QTd, QTc max and QTcd were higher in pallid attacks compared with cyanotic attacks. In patients with BHS attacks, QT max and QT min were higher in girls. The study also showed that from 90 BHS patients only 5 (5.6%) patients had pallid BHS. Tomoum et al. (15) reported that almost two-thirds (66.7%) of the patients had cyanotic spells, and one-third (33.3%) had pallid spells while Yilmaz et al. (16, 17) found the spells were cyanotic in 84.8% of all spells. In this regard, Movahedian et al. (18) reported that pallid spells were 12.5%. The present study found this ratio as 94.4% for cyanotic BHS. The highlighted difference with the reported studies is probably due to non-accounting mixed type of BHS in the present study. The present study concluded that QTd, QTc max and QTcd were higher in pallid attacks compared to patients with cyanotic attacks.

Yilmaz et al. (16, 17) in their studies concluded that QTc interval was not significantly different between patients with cyanotic and pallid BHs. In this regard, Olsen et al. (19) also did not find any difference between the patients with cyanotic and pallid attacks regarding QTc interval, which disagrees with the present study findings in the case of QTc max that is probably due to the low number of our pallid patients. In a previous study by Akalin et al. (6) it has been reported that patients with pallid or mixed BHS attacks had increased QTd compared to patients with cyanotic attacks. Autonomic nervous system dysfunction is thought to be the primary abnormality in the pathophysiology of BHS. Prolonged expiration is mediated by effects that cause the cyanotic attacks, whereas autonomic effects mediate pallid spells. Both sympathetic and parasympathetic stimulation may affect the QT interval. Al-Shahawyet al. (20) found a significant decrease in heart rate in patients with pallid episodes than those with cyanotic episodes while in our study the HR was higher in cyanotic, but not significantly. Akalın et al. (6) also resulted that QTcd values were significantly higher in patients with pallid/mixed attacks compared to the patients with cyanotic attacks. When in the present study both QTcd and QTd, as well as QTc max were higher in pallid BHS patients. Many breath-holding spells may be misdiagnosed as epileptic seizures, due to both a lack of knowledge and the fact that the attack is not observed by a health worker, and patients may be incorrectly started on antiepileptic therapy. The two conditions can be easily differentiated by means of history. EEG is frequently used to distinguish epileptic seizures from breath-holding spells.

Akpinar et al. (21) conducted a study to assess ventricular repolarization changes of QT, QTc, QTd and QTcd in children with BHs and found significant differences with controls similar to the present study results. An increase in BHS may be considered as a sign of cardiac arrhythmia. Tomoum et al. (15) concluded there was a higher QTd in BHS patients compared to controls. They also observed higher durations of bradycardia during attacks and higher occurrences of dysrhythmia during cyanotic spells, which were more frequent in patients with prolonged BHS. Olsen et al. (19) found no changes in ECG parameters in patients with BHS. Akalın et al. (6) also concluded that there was no statistical difference in heart rate, R-R interval, QT and QTc intervals in patients and controls but QTd and QTcd significantly increased. Al-Shahawy et al.

(20) reported a significant decrease in heart rate in the patients compared the control. Amoozgar et al. (22) reported that the mean of the QTcd was higher in patients, meanwhile, no significant differences were found regarding QTd. Gurbuz et al. (23) found that in all patients regardless of the type of BHS, the QTc values were lower than normal value. It seems, there is some confusion about the use of the ECG parameters for assessing cardiac involvement in BHS patients because of the contradictions in the reports; but arrhythmias and particularly prolonged QT are useful in the differential diagnosis of BHS, because autonomic nervous system dysfunction leading to QT prolongation at the time of attack has been implicated, particularly in pallid BHS.

It was reported that patients with prolonged and frequent spells had longer QT and T-wave dispersion than the control group (15). The specific cause of BHS has not been determined yet; however, it could be due to psychological or routine problems. The crucial issue in this regard is the absence of lesions and neurological problems inside the mind, and it may be considered a natural trouble that exists in some children. There is almost never any damage to the mind due to BHS, and in the future, no physical or mental troubles are anticipated (24). The action of neurons is to transmit nerve messages to different neurons. These messages are transmitted to subsequent neurons via chemical messengers known as neurotransmitters. The incidence of any seizure is due to the unexpected switch of a large number of neural messages in the mind, which usually should not be emitted from the mind. These messages can be simply produced in one a part of the mind or entire brain. Depending on where the messages start, the clinical picture of a seizure is also defined. For instance, in the event that they begin from the neurons in the motor area of the brain, the attack may start as a motion of the limbs. In a study performed by Anil et al (25), abnormality of autonomic reflexes, including increased basal heart rate, increased diastolic blood pressure, and abnormal pupillary reactions, suggested a subtle underlying generalized autonomic dysfunction in the children with breath-holding spells. Autonomic dysfunction affects intra- and interatrial conduction resulting in inhomogeneity and discontinuity in atrial conduction system. P wave dispersion (the difference between the longest and the shortest P wave duration recorded from multiple surface ECG leads) is a noninvasive method for assessment of the risk for atrial fibrillation, which is the result of inhomogeneity and discontinuity in atrial conduction.

The exact cause of the seizure has not yet been determined. The autonomic nervous system is a motor system that is involved in regulating the function of smooth muscle, heart muscle, and glands. The parasympathetic nervous system controls breathing and reduces the baby's heart rate when children with epilepsy sleep more than healthy children. Autonomic nervous system dysfunction is thought to be the primary abnormality in the pathophysiology of BHS (26). Cyanotic attacks effect mediate prolonged expirations, whereas autonomic effects mediate pallid spells. Both sympathetic and parasympathetic stimulation may affect QT interval. The higher rate of sudden death due to epilepsy compared to breathe holding can be a justification for longer QT measures in epileptic children (27).

4-1. Study Limitations

The main limitation of this study was its limitations on following-up patients. It is highly probable that by following-ups changes in cardiac evaluation of these patients, more significant abnormal ECG findings will be found.

5- CONCLUSION

From the present study it was concluded that QT, QTc, QTd and QTcd were higher in BHS. QTd, QTc max and QTcd were higher in pallid and QT max and QT min were higher in girls. To prevent probable sudden deaths, these should be given due attention especially in the case of the pallid type of BHS and with a frequency of more than one spell a day. In spite of some studies, we suggest that it is necessary to obtain ECG parameters to assess rhythm abnormality in children with BHs.

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7- CONFLICT OF INTEREST: None.

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