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Characterization of the electrocardiographic pattern of individuals with cerebral palsy

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Abstract

Background: Dentists of Lar São Francisco observed during dental treatment that children with cerebral palsy (CP) had increased heart rate (HR) and lower production of saliva. Despite the high prevalence of CP found in the literature (2.08-3.6/1000 individuals), little is known about the electrocardiographic (ECG) characteristics, especially HR, of individuals with CP.

Objective: This study aimed to investigate the hypothesis that individuals with CP have a higher HR and to define other ECG characteristics of this population.

Methods: Ninety children with CP underwent clinical examination and 12-lead rest ECG. Electrocardiographic data on rhythm, HR, PR interval, QRS duration, P/QRS/T axis, and QT, QTc and $T_{peak\text{-}end}$ intervals (minimum, mean, maximum, and dispersion) were measured and analyzed then compared with data from a control group with 35 normal children. Fisher and Mann-Whitney *U* tests were used, respectively, to compare categorical and continuous data.

Results: Groups cerebral palsy and control did not significantly differ in age (9 ± 3 × 9 ± 4 years) and male gender (65% × 49%). Children with CP had a higher HR (104.0 ± 20.6 × 84.2 ± 13.3 beats per minute; $P < .0001$), shorter PR interval (128.8 ± 15.0 × 138.1 ± 15.1 milliseconds; $P = .0018$), shorter QRS duration (77.4 ± 8.6 × 82.0 ± 8.7 milliseconds; $P = .0180$), QRS axis (46.0° ± 26.3° × 59.7° ± 24.8°; $P = .0024$) and T-wave axis (34.3° ± 28.9° × 42.9° ± 17.1°; $P = .034$) more horizontally positioned, and greater mean QTc (418.1 ± 18.4 × 408.5 ± 19.4 milliseconds; $P = .0110$). All the electrocardiogram variables were within the reference range for the age group including those with significant differences.

Conclusion: Children with CP showed increased HR and other abnormal ECG findings in the setting of this investigation. Further studies are needed to explain our findings and to correlate the increased HR with situations such as dehydration, stress, and autonomic nervous disorders.

Keywords: Cerebral palsy; Electrocardiography; ECG parameters

Introduction

Cerebral palsy (CP) describes a group of permanent movement and posture developmental disorders causing activity limitation, disorders that are imputed to nonprogressive disturbances occurring during development of the brain of the fetus or infant. CP motor disorders are often accompanied by epilepsy, secondary musculoskeletal problems, and also sensory and perceptive disturbances, cognitive impairment, and communicational and behavioral disorders.[1] This condition is the most common cause of severe physical disability during childhood,[2] with an estimated prevalence of 2.08 to 3.6 per 1000 children.[3]

Dentists of Lar Escola São Francisco, a nongovernmental organization that provides schooling, health care, and social services for handicapped CP children in the State of São Paulo, Brazil, observed during dental treatment that children with CP presented with lower production of saliva[4] and increased heart rate (HR).

Few papers were published about CP and its cardiovascular aspects, most of them studying the autonomic system. Such

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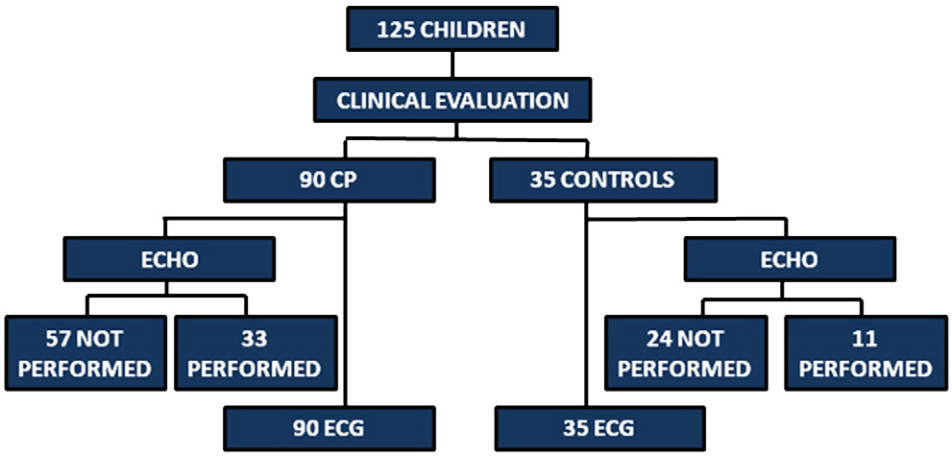

Fig. 1. Study design.

studies correlated R-R interval, PR interval, HR, and HR variability to an autonomic imbalance in this population.[5-9]

Although there were some reports describing cardiovascular aspects, there has not been any study about electrocardiographic (ECG) findings in children with CP. Our aim was to investigate the existence of an increased HR and to characterize other ECG parameters in a group of CP children.

This research project on human subjects was reviewed by the Human Research Ethics Committee of the Heart Institute (InCor)-University of São Paulo Institutional Review Board in compliance with the principles of the Declaration of Helsinki. After being informed of the aim of the investigation, written informed consent for participation and publication was obtained from the adult responsible for each child/individual who agreed to participate in the study.

Study design

Participants

A convenience sample composed by 90 individuals with CP with ages ranging 3 to 16 years who were being treated at Lar Escola São Francisco were included in this study (Fig. 1). Inclusion criteria were individuals with confirmed diagnosis of CP aged 3 to 16 years, both sex, and informed consent signed by parents/caregivers. Exclusion criteria was previous history of cardiac diseases.

The patients' medical records were reviewed for demographic and clinical data including sex, age, and medications used routinely.

A control group (CG) was composed by 35 CP siblings aged 3 to 16 years. No one had any systemic condition nor had they taken any medication at least on the 15 days before the study tests.

In the clinical evaluation of participants, all the CP patients and controls were clinically evaluated by a practicing cardiologist including anamnesis.

12-Lead ECG

12-lead ECG recordings of 4 × 3 format were performed on a Cardiofax ECG-9620 (Nihon Kohden, Tokyo, Japan) equipment at a 25 mm/s speed and 10 mV gain with individuals in horizontal decubitous position in a quiet environment. A practicing cardiologist blinded to the echocardiographic and clinical data analyzed all the recordings. The following ECG variables were obtained: HR; PR interval; QRS duration; QT interval; P-wave axis; QRS axis; T-wave axis; manual measurements of minimum, maximum, and mean corrected QT intervals (QTc) and QTc dispersion; and $T_{peak\text{-}end}$ minimum, maximum, and mean intervals and its dispersion.

Echocardiography

The study subjects underwent M-mode and B-mode (2-dimensional) pulse Doppler echocardiography using a Sequoia 512 system equipped with a 2.5 to 4.0 MHz multifrequency model 3V2c transducer (Acuson, Mountain View, CA). Continuous and color Doppler flows were recorded in thermosensitive paper from both the 4- and 2-chamber parasternal long- and short-axis views at the level of the aorta/left atrium, mitral valve, and papillary muscle with subjects in left lateral decubitus position and their heads elevated at 30°. To characterize that the study subjects' hearts did not have anatomical disorders that might cause alterations in the heart conduction system, the variables assessed were left ventricular diastolic and systolic diameters, posterior wall and septum thickness, HR, and systolic function using the modified biplane Simpson rule.

Statistical analysis

Data are presented as mean ± SD. Histograms of the data showed that the distributions were non-Gaussian. For statistical analysis, Mann-Whitney *U* tests compared continuous data, and Fisher exact test compared categorical data. Statistical significance was established at $P \leq .05$.

Results

The study groups revealed statistically similar age and sex data (Table 1).

Table 1
Characteristics of the CG and CPG

Variables	Units	CG (n = 35)	CPG (n = 92)	P^a
Age	y	9.0 ± 4.4	9.3 ± 3.1	.44
Male gender	%	48.6	65.2	.17

CPG indicates cerebral palsy group.
[a] Fisher and Mann-Whitney *U* tests comparing CG to CPG; $P < .05$.

Results of the clinical evaluation and ECG findings were within the reference range for the age group for all the individuals, as displayed in Table 2. However, compared with the CG, patients with CP had a higher HR (104.0 ± 20.6 × 84.2 ± 13.3 beats per minute; $P < .0001$), shorter PR interval (128.8 ± 15.0 × 138.1 ± 15.1 milliseconds; $P = .0018$), shorter QRS duration (77.4 ± 8.6 × 82.0 ± 8.7 milliseconds; $P = .0180$), QRS axis (46.0° ± 26.3° × 59.7° ± 24.8°; $P = .0024$) and T-wave axis (34.3° ± 28.9° × 42.9° ± 17.1°; $P = 0{,}034$) more horizontally positioned, and greater mean QTc (418.1 ± 18.4 × 408.5 ± 19.4 milliseconds; $P = .0110$).

Echocardiography was performed on 33 CP individuals and 11 controls who could attend the test schedule. The other children were summoned to perform the examination, but they could not do it because they either did not have a good acoustic window or did not collaborate or their parents/caregivers did not authorize performance of the examination.

Echocardiographic parameters were all within the reference range except for HR (Table 3).

Table 3
Echocardiographic parameters in the CG and CPG

Parameters, units	CG (n = 11)	CPG (n = 33)	P^a
LVDD, mm	35.18 ± 7.26	32.70 ± 5.94	.3496
LVSD, mm	20.73 ± 5.83	19.15 ± 3.77	.4642
Septum, mm	6.18 ± 1.47	5.85 ± 1.06	.5963
PW, mm	6.45 ± 1.29	5.67 ± 0.99	.1003
HR, beats per min	79.36 ± 12.50	96.79 ± 18.21	.0115
EF, %	70.33 ± 1.15	72.69 ± 6.01	.5665

LVDD indicates left ventricle diastolic diameter; LVSD, left ventricle systolic diameter; PW, left ventricle posterior wall; EF, ejection fraction.
[a] Mann-Whitney *U* test comparing CG to CPG; $P < .05$.

Discussion

CP is a permanent disorder encompassing different types of neuromotor abnormalities and clinical patterns of involvement. This study was the first to evaluate clinical and ECG aspects in CP individuals, comparing their results with those from their siblings thereby providing comparisons between individuals with similar genetic background, socioeconomic level, and environment.

The pediatric ECG characteristics must be considered in accordance with the children's ages. Many times, it is necessary to consult tables to check the standard values. One of the most important tables was published by Davignon et al[10] in 1979, which divided the children in 12 classes of age. In this study, the children with and without CP had, on average, 9.0 and 9.3 years, respectively. They were classified within the group of 8 to 12 years of the Davignon's table.

For children 8 to 12 years, the HR should be 62 to 130 beats per minute.[10] In this study, the children with CP showed mean HR of 104 beats per minute and the control children, 87 beats per minute. Despite the significant difference between the 2 groups ($P < .0001$), both have values within the reference range.

Most children with CP could not understand what was happening during the ECG examinations, so it is possible that they became frightened. This stressful situation may justify the increase in HR. Furthermore, there are other hypotheses that could explain this finding such as dehydration and autonomic nervous system disorders.

Children with CP generally cannot care for themselves and need help to eat and drink. It is possible that caregivers did not give them enough water, thus leading to dehydration that might have caused increases in HR.

In 1997, Yang et al[7] did not find evidences of autonomic disturbances in patients with CP under relaxed sitting condition, but 2 papers[5-8] published in 2002 observed

Table 2
Electrocardiographic variables (mean ± SD) in the CG and CPG

Variables	Units	CG (n = 35)	CPG (n = 92)	P^a
HR	beats per min	84.17 ± 13.28	104.0 ± 20.65	<.0001
PR	milliseconds	138.11 ± 15.09	128.8 ± 14.99	.0018
QRS duration	milliseconds	82.0 ± 8.69	77.38 ± 8.64	.018
ÂP	degrees	37.37 ± 17.32	41.40 ± 22.79	.3590
ÂQRS	degrees	59.71 ± 24.79	45.97 ± 26.27	.0024
ÂT	degrees	42.86 ± 17.11	34.34 ± 28.85	.0340
QTc minimum	milliseconds	380.97 ± 27.18	389.05 ± 23.99	.1010
QTc maximum	milliseconds	432.30 ± 23.59	442.26 ± 25.53	.1027
QTc mean	milliseconds	408.54 ± 19.35	418.08 ± 18.40	.0110
QTc dispersion	milliseconds	51.33 ± 25.66	53.21 ± 25.22	.2505
$T_{peak\text{-}end}$ minimum	milliseconds	61.71 ± 11.24	54.78 ± 10.64	.0109
$T_{peak\text{-}end}$ maximum	milliseconds	104.57 ± 18.21	98.91 ± 19.52	.2049
$T_{peak\text{-}end}$ mean	milliseconds	81.05 ± 6.8	76.18 ± 9.92	.0058
$T_{peak\text{-}end}$ dispersion	milliseconds	42.86 ± 19.49	44.13 ± 17.92	.6867

PR indicates PR interval; ÂP, P-wave axis; ÂQRS, QRS axis; ÂT, T-wave axis.
[a] Mann-Whitney *U* test comparing CG to CPG; $P < .05$.

significant differences in the sympathovagal balance when the children with CP were submitted to stressing conditions. The autonomic nervous system influences the HR, and a disorder in this system may explain the higher HR in CP children. However, we could not find in the literature any study showing an increased HR level in this population.

The CP children showed PR interval and QRS duration higher than the normal ones. The PR interval and QRS duration probably were influenced by the significant differences in the HR.

The P wave and QRS complex axis are parameters used to establish the cardiac chambers orientation in the frontal plan. The definition of atrial situs is based on the location of the sinus node. In the situs solitus, the P-wave axis is located between 0° and 90°. The data found, 37° and 41° for the control and the CP groups, respectively, show that both groups have situs solitus.

The QRS complex axis is influenced both by the cardiac position and the patient's posture. In the children with CP, it was observed that the QRS complex axis was more horizontally positioned. The children with CP frequently have alterations of posture caused by the paralysis, which may have influenced the results of QRS complex axis.

Other parameters that do not have well-known pediatric values were analyzed. From these parameters, we found significant differences in QTc mean, $T_{peak\text{-}end}$ mean and $T_{peak\text{-}end}$ minimum.

This study was not designed to explain the alterations in ECG parameters. However, we think it is important to establish ECG characteristics of this population because they may be used as a reference for further investigation that will try to explain if the increase in HR could be related to situations such as dehydration, stress, or autonomic nervous disorders.

Study limitations

Some possible limitations in this study may have confused the statistical analyses. Firstly, echocardiogram and ECG were done in different days showing different states of humor and stress. Secondly, some children did not collaborate with the examinations thus decreasing the sample size. Finally, most children with CP have an unusual posture, which might have contributed for the QRS and T-axis deviations.

Conclusion

Children with CP showed increased HR and other abnormal ECG findings in the setting of this investigation. Further studies are needed to explain our findings and to correlate the increased HR with situations such as dehydration, stress, and autonomic nervous disorders.

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