

How to Cite:

Ahmed, M. S., Marghany, K. A., Rahhal, A. E. I. A., & Zahran, A. M. (2022). Holter study in Epileptic. *International Journal of Health Sciences*, 6(S3), 12356–12365.
<https://doi.org/10.53730/ijhs.v6nS3.9082>

Holter study in Epileptic

Mohamed Saeed Ahmed

Cardiology Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt
*Corresponding author email: doctrika@gmail.com

Kamal Ahmed Marghany

Cardiology Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Abd Elhamid Ismail Abu Rahhal

Cardiology Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Alhassan Mostafa Zahran

Pediatrics Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Abstract---Introduction: Heart rate variability have the potential to serve as a biomarker of SUDEP risk, allowing for increased counselling of patients and their families and serving as a valuable outcome measure for research aimed at developing drugs and therapies to reduce SUDEP risk. The sympathetic and parasympathetic modulatory activities of cardiac nerves result in a Holter test lasting less than 24 hours (a few minutes). Objective: for detection of heart rate variability and cardiac arrhythmias in epileptic children. Materials and methods: This cross-sectional study was carried out on 100 children with epilepsy. All patients were subjected to: history taking, full physical examination, echocardiography, 24 hours Holter, EEG, MRI brain, Standard 12-derivation ECG (including V4 R derivation). Results: There was a significant variability in HF, LF, LF/HF, RMSSD, SDNN and PNN50 among all time measurements throughout the day (P values <0.001). Heart rate variability was significantly worse in younger patients aged less than 10 years than others and was found comparable between males and females (P values > 0.05). Heart rate variability was significant in relation to EEG localization (All P<0.001) being worse in case of left temporal localization when compared to other types. Conclusions: Holter recordings may be beneficial for identifying a cardiovascular risk increase in epilepsy.

Keywords---holter study, epileptic children, heart rate variability, cardiac arrhythmias.

Introduction

The mechanism responsible for sudden unexpected death in epilepsy (SUDEP) remains poorly understood. The incidence of SUDEP is devastating and alarming. Widespread perception believes that SUDEP is caused by a seizure, generally convulsive and typically, but not always, occurring during sleep, followed by a sequence of postictal events beginning with breathing trouble and concluding in cardiac asystole and death (Verrier, Pang, Nearing, & Schachter, 2020). The relationship between anomalies in heart rate variability and SUDEP in children with epilepsy may be due to mutations in sodium channels or aberrant autonomic tone caused by accumulating cardiac damage from frequent seizures (Myers, Sivathamboo, & Perucca, 2018). Patients with epilepsy exhibit altered heart rate variability, indicating a shift toward sympathetic dominance in the autonomic balance (Myers et al., 2018). In patients with epilepsy, the normal diurnal change in heart rate variability is also altered.

Measuring heart rate variability has the potential to aid in the therapeutic management of epilepsy in a number of ways. Variability of heart rate may aid in the identification of children who may benefit from surgical procedures such as vagus nerve stimulation and targeted brain resection (Myers et al., 2018). Eventually, heart rate variability may have the potential to act as a biomarker of SUDEP risk, allowing for more patient and family counselling and serving as a relevant outcome measure for research targeted at creating medications and treatments to lower SUDEP risk (Myers et al., 2018). The aim of this work was for detection of heart rate variability and cardiac arrhythmias in epileptic children.

Materials and Methods

This cross-sectional study was carried out on 100 children aged from 3 to 18 years old, with epilepsy at Cardiovascular Department, Al_Hussein Hospital, Al Azhar University and National heart institute. The study was performed after being approved from institutional ethical committee, Al Azhar University. Informed written consent was obtained from the patients' relatives.

Inclusion criteria

Children on broad spectrum antiepileptic drugs (sodium valproate – phenytoin – carbamazepine) and with any type of seizures activity.

Exclusion criteria

Age less than 3 years or more than 18 years, congenital heart diseases, adjuvant epileptic drug, with other neurological problems as (encephalitis, hemiplegia, neurodegenerative diseases, etc.) and with only one attack of seizures. All patients were subjected to: history taking, full physical examination, echocardiography, 24 hours Holter, EEG, MRI brain, Standard 12-derivation ECG (including V4 R derivation).

Echocardiography

Echocardiographic examination was performed with M-mode, 2-dimensional, color, pulse and continuous wave Doppler echocardiograms. Two-dimensional echocardiographic images were captured in conventional parasternal short axis, long axis, apical 4-chamber, subcostal, and suprasternal perspectives. ECG sampling was performed only once. ECG data were analyzed to determine the T morphology, QRS, PR, QT, corrected QT intervals, and QT dispersions for each patient. QTc was calculated via “Bazzet” ($QTc = QT/RR^{1/2}$) formula.

Heart rate variability

Using computerized holter monitoring equipment, twenty-four hours of holter monitoring were undertaken. The research of heart rate variability was based on an ECG signal sampled at 100 Hz for 24 hours and recorded digitally. The processed signal originates from electrodes on the chest surface. The algorithm detected and labeled QRS complexes automatically, which were then manually reviewed to minimise the chance of artifacts. The temporal parameters analyzed were the mean of the RR interval (mean RR), the standard deviation of the difference between consecutive RR intervals (SDANN), the standard deviation of RR interval (SDNN), the root mean square of difference between successive normal intervals (RMSSD) and both absolute and normalized low frequency (LF: 0.04–0.15 Hz).

High frequency (HF: 0.15–0.4 Hz) spectral powers were evaluated. The LF value is mostly a measure of sympathetic activity, with some parasympathetic effect. The HF value represents parasympathetic activity alone. The integral of the density distribution (that is, the number of all NN intervals) is divided by the maximum of the density distribution to get the triangular index. It may be used to estimate HRV as a whole. We analyzed the HRV parameter for 24 h. Also, parameters were evaluated again in two different time periods as daytime (between 7:00–12.00 am), and night-time (between 12:00–7:00 am). Holter monitorization of the study group was done simultaneously during the video EEG monitorization. Therefore, we could also evaluate the HRV parameters during the seizure.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD). Unpaired Student's t- test was used to compare each two groups. More than two groups were compared utilizing ANOVA (F) test. We performed Repeated measures ANOVA test to compare different time measurements of the same variable. Qualitative variables were presented as frequency and percentage (%). A two tailed P value ≤ 0.05 was considered statistically significant.

Results

Table (I) shows demographic data, ECG type, and Holter monitoring, ECG parameters, Echo, MRI and EEG localization of arrhythmias of the studied patients. There was a significant variability in HF, LF, LF/HF, RMSSD, SDNN and

PNN50 among all time measurements throughout the day (P values <0.001). Table (II). Heart rate variability was significantly worse in younger patients aged less than 10 years than others and was found comparable between males and females (P values > 0.05). Table (III). Heart rate variability was significant in relation to EEG localization (All P<0.001) being worse in case of left temporal localization when compared to other types. (Table IV). Male children patient 7 years old presented to Emergency room of AL Hussein hospital crying from recurrent attacks of palpitations. Without any known sickness, he looked to be developing appropriate motor and language abilities and had no prenatal complications. Nonetheless, he had a history of epilepsy at age 5. Consequently, he was taking various broad-spectrum antiepileptics.

- Echo cardiography: Normal.
- Resting ECG: Sinus Tachycardia
- Cardiac Holter Monitorization: Episodes of Sinus Tachycardia (Figure I).

The patient was a thirteen old girl presented to the outpatient clinic, National Heart Institute for routine cardiac investigations, as her sibling suffered from cardiac problems. She was the second of two children and experienced her first seizure at the age of six. Therefore, she was taking numerous antiepileptics with a broad range. Pregnancy and childbirth were unexceptional. Likewise, the family history was ordinary. Early developmental milestones were somewhat behind schedule (walked at 16 months).

- Echo cardiography: Normal.
- Resting ECG: Normal
- Cardiac Holter Monitorization: Episodes of Sinus Tachycardia (Figure II).

Discussions

Epilepsy is a chronic condition characterized by repeated seizures. It was previously believed that seizure control was sufficient to avert problems (Dagar et al., 2020). Heart rate variability measures give a simple, noninvasive method for evaluating the heart's autonomic control function. HRV time series regression is most accurate in predicting SUDEP. The measurement of heart rate variability provides a simple, noninvasive method for monitoring the heart's autonomic regulation function (Gimeno-Blanes, Blanco-Velasco, Barquero-Pérez, García-Alberola, & Rojo-Álvarez, 2016). Holter of 24 h or less (a few minutes) is the result of sympathetic and parasympathetic nervous system activation of cardiac neurons (Van Voorhees et al., 2022). Therefore, the current study was conducted to assess whether heart rate could be considered as a biomarker for the SUPED in epilepsy.

The present study showed that regarding ECG types, 88 (88%) patients had normal ECG, 11 (11%) patients had sinus tachycardia and 1 (1%) patient had incomplete right bundle branch block (IRBBB). In contrary, Serdyuk et al. (Serdyuk et al., 2021) performed a total of 6494 electrocardiogram traces during the median follow-up of 36 months to evaluate the frequency and type of cardiac arrhythmias in patients with drug-resistant epilepsy and reported that the most common ECG type was ictal sinus tachycardia (66.8%). The discrepant sample

size and the resistance to epileptic drugs recorded in Serdyuk et al. study may account for the contradictory results. PVCs burden: ranged from 1-2 % of total QRS count, PACs burden: ranged from 2-3 % of total QRS count, No ST segment elevation or depression was noted.

Our results are contrasted to Baysal-Kirac et al. (Baysal-Kirac et al., 2017) who examined the correlations between cardiac autonomic functions based on heart rate variability (HRV) characteristics and SUDEP risk variables in 47 consecutive individuals with drug-resistant epilepsy. Holter monitoring revealed that the presenting arrhythmia for sudden cardiac arrest (SCA) was less likely to be sinus tachycardia and more likely to be bradycardia in epileptic patients, indicating a greater parasympathetic tone. Shaffer et al. (Shaffer, McCraty, & Zerr, 2014) revealed that Holter monitoring is more accurate than an ECG in detecting disturbances in the heart's rhythm because it is attached to the heart for a significantly longer period of time. Thus, it could be effective in evaluating cardiac state in epileptic patients. In addition, all participant in the present study exhibited normal Echo. Furthermore, regarding brain MRI most of patients showed normal MRI (76%), 4 (4%) patients had temporal lobe dysplasia, 7 (7%) patients had occipital calcified lesion, 5 (5%) patients had gliotic lesion in internal capsule, 5 (5%) patients had bilateral hippocampal sclerosis and 3 (3%) patients had bilateral sylvian polymicrogyria and schizencephaly.

Further, Wang et al. (Wang et al., 2019) carried out a consecutive cohort of pediatric epileptic patients undergoing pre-surgical evaluation with MRI by visual analysis. The results showed that about half of patients 47% had normal MRI while 53% had a suspicious MRI abnormality including focal cortical dysplasia (FCD), abnormal signal in the temporal lobe as well as hippocampal volume loss. Contrasted to our results, Kumari et al. (Kumari, Jyothi, Chandra, Pushpanjali, & Jayalatha, 2017) showed that 41% of epileptic patients had normal MRI while 59% of them had MRI findings including space occupying lesion/tumour in left parietal and temporal lobe, open-lip schizencephaly with cortical dysplasia and sturge-weber syndrome. The current work revealed that EEG localization of the studied patients 14% were generalized, 16% left frontal, 10% left temporo-occipital, 13% temporal, 27% left temporal, 10% left temporo-central onset, 10% bilateral central onset.

Further, regarding ECG localization Işık et al. (Işık, Ayabakan, Tokel, & Ozek, 2012) reported that 33% of the studied patients were generalized, 5.5% left frontal, 11.1% left temporo-occipital, 5.5% temporal, 5.5% left temporal, 28.9% left temporo-central onset and 11.1% bilateral central onset. According to previous research, enhanced seizure detection and monitoring to intervene early during a seizure may be one way to lower the incidence of SUDEP. Enhanced seizure surveillance may minimize the risk of other causes of death, such as trauma, drowning, choking, and aspiration, in individuals with epilepsy (Morse & Kothare, 2016). However, Nashef et al. (Nashef, So, Ryvlin, & Tomson, 2012) found that seizure durations more than or equal to 30 minutes or the absence of recovery between seizures do not indicate the cause of death.

Additionally, the present study evaluated the ECG parameters of the studied children, QT-min of the studied patients ranged from 0.2 – 0.4 seconds with a

mean of 0.3 ± 0.08 seconds. QT-max of the studied patients ranged from 0.2 – 0.5 seconds with a mean of 0.3 ± 0.11 seconds. RR of the studied patients ranged from 0.1 – 1.3 seconds with a mean of 0.8 ± 0.4 seconds. HR of the studied patients ranged from 70 – 189 beat/min with a mean value of 123.9 ± 37.06 beat/min. S in V1 of the studied patients ranged from 0.2 – 1 seconds with a mean of 0.6 ± 0.25 seconds. R in V5 of the studied patients ranged from 0.07 - 2.05 seconds with a mean of 1.1 ± 0.6 seconds. R in aVL of the studied patients ranged from 0.1 - 0.9 seconds with a mean of 0.5 ± 0.28 seconds. S in V3 of the studied patients ranged from 0.2 - 1.6 seconds with a mean of 0.9 ± 0.43 seconds.

QTd of the studied patients ranged from 0.01 - 0.09 seconds with a mean of 0.1 ± 0.03 seconds. QTC min of the studied patients ranged from 0.2 - 0.6 seconds with a mean of 0.4 ± 0.13 seconds. QTcd of the studied patients ranged from 0.03 - 0.1 seconds with a mean of 0.1 ± 0.02 seconds. QTC max of the studied patients ranged from 0.4 - 0.6 seconds with a mean of 0.5 ± 0.08 seconds. LV mass of the studied patients ranged from 45 – 55 gm with a mean of 49.1 ± 2.94 gm. Further, Noori et al. (Noori, Khajeh, Akhlaghi, & Teimouri, 2019) conducted a case-control research with 90 patients aged 6 months to 18 years to compare the electrocardiography results of children with epilepsy to those of healthy children. The QT min, R-R interval, heart rate, S in V1, S in V3, R in aVL, QTcd, QTd, LV mass, and QTC max were significantly elevated in epileptic patients.

In addition, our results are in line with Dagar et al. (Dagar et al., 2020) who evaluated the ECG parameters of the studied children and found that QT-min of the studied patients was 0.31 seconds. QT-max of the studied patients ranged was 0.35 seconds. On the other hand, Kolsal et al. (Kolsal et al., 2014) investigated interictal, preictal, and ictal disturbances of the autonomic nervous system by comparing the heart rate variability of children with uncontrolled epilepsy to that of children with treated epilepsy and healthy controls. QT and QTc dispersion have been utilized as markers of ventricular repolarization. It has been demonstrated that a prolonged QTc increases vulnerability to arrhythmias. It has been demonstrated that epileptic patients have QTc prolongation independent of medication usage.

In harmonious with our findings, Lamberts et al. (Lamberts et al., 2015) examined the link between cardiac arrest and ECG and discovered that epileptic patients had a greater average heart rate and a longer QTc length. Krishnan and Krishnamurthy (Krishnan & Krishnamurthy, 2013) detected longer QTc and PR intervals in epileptic patients. de Sousa et al. (de Sousa, Fialho, Wolf, Walz, & Lin, 2017) suggested that epileptic patients had longer P, PR, and QTc intervals as well as elevated QTcd values, despite the fact that heart rates, QRS complexes, and RR intervals were unchanged. According to medical literature, electrocardiographic problems include longer QT and QTc intervals, as well as higher heart rates and QTcd values.

The preictal and ictal ECG and EEG recordings of epileptic patients were collected as part of a study investigating the feasibility of using ECG features to predict seizures. These results indicate that heart rate variability (HRV) linked with sympathetic and parasympathetic modulation, particularly before to and during seizures, may serve as a marker for seizures (Osorio & Manly, 2015). In addition

to HRV, morphologic alterations have been seen in the ST segment, T-wave, and QRS complex on ECGs during the peri-ictal phase (Osorio, 2014). It is theorized that these symptoms are caused by the effects of convulsive activity on the central autonomic network, which alter cardiac action.

Limitations

It was a single center study with a relatively small sample size, also mortality rate and correlation between results was not investigated.

Conclusions

Our results detected that epileptic child have increased heart rate (sinus tachycardia), also increased QTd, QTc, QTcd, RR and LV mass values. This was more related to younger age less than 10 years, left temporal type of epilepsy, and was nearly equal in both sexes. Our results also revealed that heart rate variability increase during night comparing to daytime. Holter recordings may be beneficial for identifying a cardiovascular risk increase in epilepsy.

Acknowledgements: Nil

References

- Baysal-Kirac, L., Serbest, N. G., Şahin, E., Dede, H. Ö., Gürses, C., Gökyiğit, A., . . . Baykan, B. (2017). Analysis of heart rate variability and risk factors for SUDEP in patients with drug-resistant epilepsy. *Epilepsy Behav*, 71, 60-64.
- Dagar, S., Emektar, E., Corbacioglu, S. K., Demirci, O. L., Tandogan, M., & Cevik, Y. (2020). Evaluation of electrocardiographic parameters in patients with epileptic seizure. *Acta Neurol Belg*, 120(2), 321-327. doi:10.1007/s13760-019-01182-8
- de Sousa, J. M., Fialho, G. L., Wolf, P., Walz, R., & Lin, K. (2017). Determining factors of electrocardiographic abnormalities in patients with epilepsy: A case-control study. *Epilepsy Res*, 129, 106-116. doi:10.1016/j.epilepsyres.2016.12.011
- Gimeno-Blanes, F. J., Blanco-Velasco, M., Barquero-Pérez, Ó., García-Alberola, A., & Rojo-Álvarez, J. L. (2016). Sudden Cardiac Risk Stratification with Electrocardiographic Indices - A Review on Computational Processing, Technology Transfer, and Scientific Evidence. *Front Physiol*, 7, 11-23. doi:10.3389/fphys.2016.00082
- Işik, U., Ayabakan, C., Tokel, K., & Ozek, M. M. (2012). Ictal electrocardiographic changes in children presenting with seizures. *Pediatr Int*, 54(1), 27-31. doi:10.1111/j.1442-200X.2011.03453.x
- Kolsal, E., Serdaroglu, A., Cilsal, E., Kula, S., Soysal, A., Kurt, A. N., & Arhan, E. (2014). Can heart rate variability in children with epilepsy be used to predict seizures? *Seizure*, 23(5), 357-362. doi:10.1016/j.seizure.2014.01.025
- Krishnan, V., & Krishnamurthy, K. B. (2013). Interictal 12-lead electrocardiography in patients with epilepsy. *Epilepsy Behav*, 29(1), 240-246. doi:10.1016/j.yebeh.2013.07.021

- Kumari, M. V., Jyothi, J. A., Chandra, A. S., Pushpanjali, V., & Jayalatha, N. (2017). Role of magnetic resonance imaging in paediatric epilepsy. *J evol med dent sci*, 6(6), 494-509.
- Lamberts, R. J., Blom, M. T., Novy, J., Belluzzo, M., Seldenrijk, A., Penninx, B. W., . . . Thijs, R. D. (2015). Increased prevalence of ECG markers for sudden cardiac arrest in refractory epilepsy. *J Neurol Neurosurg Psychiatry*, 86(3), 309-313. doi:10.1136/jnnp-2014-307772
- Morse, A. M., & Kothare, S. V. (2016). Pediatric Sudden Unexpected Death in Epilepsy. *Pediatr Neurol*, 57, 7-16. doi:10.1016/j.pediatrneurol.2016.01.004
- Myers, K. A., Sivathamboo, S., & Perucca, P. (2018). Heart rate variability measurement in epilepsy: How can we move from research to clinical practice? *Epilepsia*, 59(12), 2169-2178. doi:10.1111/epi.14587
- Nashef, L., So, E. L., Ryvlin, P., & Tomson, T. (2012). Unifying the definitions of sudden unexpected death in epilepsy. *Epilepsia*, 53(2), 227-233. doi:10.1111/j.1528-1167.2011.03358.x
- Noori, N., Khajeh, A., Akhlaghi, E., & Teimouri, A. (2019). Electrocardiography Findings in Children with Epilepsy Compared with Healthy Children. *Int J Pediatr*, 7(8), 9783-9792. doi:10.22038/ijp.2019.39799.3386
- Osorio, I. (2014). Automated seizure detection using EKG. *Int J Neural Syst*, 24(2), 14-19. doi:10.1142/s0129065714500014
- Osorio, I., & Manly, B. F. (2015). Probability of detection of clinical seizures using heart rate changes. *Seizure*, 30, 120-123. doi:10.1016/j.seizure.2015.06.007
- Serdyuk, S., Davtyan, K., Burd, S., Drapkina, O., Boytsov, S., Gusev, E., & Topchyan, A. (2021). Cardiac arrhythmias and sudden unexpected death in epilepsy: Results of long-term monitoring. *Heart Rhythm*, 18(2), 221-228. doi:10.1016/j.hrthm.2020.09.002
- Shaffer, F., McCraty, R., & Zerr, C. L. (2014). A healthy heart is not a metronome: an integrative review of the heart's anatomy and heart rate variability. *Front Psychol*, 5, 10-40. doi:10.3389/fpsyg.2014.01040
- Van Voorhees, E. E., Dennis, P. A., Watkins, L. L., Patel, T. A., Calhoun, P. S., Dennis, M. F., & Beckham, J. C. (2022). Ambulatory Heart Rate Variability Monitoring: Comparisons Between the Empatica E4 Wristband and Holter Electrocardiogram. *Psychosom Med*, 84(2), 210-214. doi:10.1097/psy.0000000000001010
- Verrier, R. L., Pang, T. D., Nearing, B. D., & Schachter, S. C. (2020). The Epileptic Heart: Concept and clinical evidence. *Epilepsy Behav*, 105, 10-16. doi:10.1016/j.yebeh.2020.106946
- Wang, W., Lin, Y., Wang, S., Jones, S., Prayson, R., Moosa, A. N. V., . . . Wang, Z. I. (2019). Voxel-based morphometric magnetic resonance imaging postprocessing in non-lesional pediatric epilepsy patients using pediatric normal databases. *Eur J Neurol*, 26(7), 969-971. doi:10.1111/ene.13916
- Kustina, K.T., Dewi, G.A.A.O., Prena, G.D., Suryasa, W. (2019). Branchless banking, third-party funds, and profitability evidence reference to banking sector in indonesia. *Journal of Advanced Research in Dynamical and Control Systems*, 11(2), 290-299.
- Nyandra, M., Kartiko, B.H., Susanto, P.C., Supriyati, A., Suryasa, W. (2018). Education and training improve quality of life and decrease depression score in elderly population. *Eurasian Journal of Analytical Chemistry*, 13(2), 371-377.
- Khidoyatova, M. R., Kayumov, U. K., Inoyatova, F. K., Fozilov, K. G., Khamidullaeva, G. A., & Eshpulatov, A. S. (2022). Clinical status of patients

Tables

Table I

Demographic data, ECG type, and holter monitoring, ECG parameters, Echo, MRI and EEG localization of arrhythmias of the studied patients

		n=100
Age (years)		10 ± 4.75
Sex	Male	62 (62%)
	Female	38 (38%)
Height (m)		1.4 ± 0.24
Weight (kg)		41.3 ± 15.03
BMI (kg/m ²)	Mean ± SD	24.1 ± 12.43
AED	(Broad spectrum antiepileptic drugs)	100 (100%)
ECG type	Normal	88 (88%)
	sinus tachycardia	11 (11%)
	IRBBB	1 (1%)
ECG risk findings	Serious arrhythmias	0 (0%)
	Normal	17 (17%)
	sinus tachycardia	83 (83%)
ECG parameters	QT-min (seconds)	0.3 ± 0.08
	QT-max (seconds)	0.3 ± 0.11
	RR (seconds)	0.8 ± 0.4
	HR (beats/min)	123.9 ± 37.06
	S in V1 (seconds)	0.6 ± 0.25
	R in V5(seconds)	1.1 ± 0.6
	R in aVL (seconds)	0.5 ± 0.28
	S in V3 (seconds)	0.9 ± 0.43
	QTd (seconds)	0.1 ± 0.03
	QTC min (seconds)	0.4 ± 0.13
	QTcd (seconds)	0.1 ± 0.02
	QTC max (seconds)	0.5 ± 0.08
	LV mass(gm)	49.1 ± 2.94
Echo	Normal	100 (100%)
	Abnormal	0 (0%)
MRI	Normal	76 (76%)
	Temporal lobe dysplasia	4 (4%)
	Occipital calcified lesion	7 (7%)
	Gliotic lesion in internal capsule	5 (5%)
	Bilateral hippocampal sclerosis	5 (5%)
	Bilateral sylvian polymicrogyria and schizencephaly	3 (3%)
EEG localization	Generalized	14 (14%)
	Left frontal	16 (16%)

	Left temporo-occipital	10 (10%)
	Temporal	13 (13%)
	Left temporal	27 (27%)
	Left temporocentral onset	10 (10%)
	Bilateral central onset	10 (10%)

Data are presented as mean \pm SD or frequency (%). BMI: Body mass index, AED: antiepileptic d, ECG: Electrocardiogram, IRBBB: incomplete right bundle branch block, IRBBB: incomplete right bundle branch block, PVCs: Premature Ventricular Contractions, R in aVL: The amplitude of R wave in the left hand lead, 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, RR: R-R interval, HR: Heart rate, S in v1: The amplitude of S wave in the right precordial lead, PACs: Premature atrial contractions, R in v5: The amplitude of R wave in the left precordial lead, S in V3: the amplitude of S wave in the left Precordial lead QTd: QT max-QT min, QTcd: QTc max-QTc min, MRI: Magnetic resonance imaging, LVM: Left ventricular mass, EEG: Electroencephalogram.