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Heart rate changes during partial seizures: A study amongst Singaporean patients

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Abstract

Introduction: Studies in Europe and America showed that tachycardia, less often bradycardia, frequently accompanied partial seizures in Caucasian patients. We determine frequency, magnitude and type of ictal heart rate changes during partial seizures in non-Caucasian patients in Singapore.

Methods: Partial seizures recorded during routine EEGs performed in a tertiary hospital between 1995 and 1999 were retrospectively reviewed. All routine EEGs had simultaneous ECG recording. Heart rate before and during seizures was determined and correlated with epileptogenic focus. Differences in heart rate before and during seizures were grouped into 4 types: (1) >10% decrease; (2) -10 to +20% change; (3) 20–50% increase; (3) >50% increase.

Results: Of the total of 37 partial seizures, 18 were left hemisphere (LH), 13 were right hemisphere (RH) and 6 were bilateral (BL) in onset. 51% of all seizures showed no significant change in heart rate (type 2), 22% had moderate sinus tachycardia (type 3), 11% showed severe sinus tachycardia (type 4), while 16% had sinus bradycardia (type 1). Asystole was recorded in one seizure. Apart from having more tachycardia in bilateral onset seizures, there was no correlation between side of ictal discharge and heart rate response. Compared to Caucasian patients, sinus tachycardia was considerably less frequent. Frequency of bradycardia was similar to those recorded in the literature.

Conclusions: Significant heart rate changes during partial seizures were seen in half of Singaporean patients. Although sinus tachycardia was the most common heart rate change, the frequency was considerably lower compared to Caucasian patients. This might be due to methodological and ethnic differences. Rates of bradycardia are similar to those recorded in the literature.

Introduction

The association between seizures and heart rate changes has been documented in several studies conducted in Caucasian patients with partial seizures [1–4]. The clinical relevance of cerebral arrhythmogenesis in contributing to epilepsy mortality has been repeatedly highlighted in publications and has become a major focus in the discussions dealing with epilepsy mortality [5–10]. However, caution needs to be exerted in applying results obtained from one ethnic group to another, as significant

differences in organ function and regulation are known to exist between varying ethnic groups. To test whether this may be the case for the ictal heart rate variations, we set out to determine the frequency, magnitude and type of ictal heart rate changes encountered in a tertiary neurological referral center in Singapore.

Patients and Methods

Partial seizures recorded during routine EEGs performed in a tertiary hospital between 1995 and 1999 were retrospectively reviewed. All routine EEGs had simultaneous ECG recording. Routine EEG recording was performed in the neurodiagnostic laboratory in a recumbent position. Patients were routinely encouraged to relax during the 30-minute procedure. The 10/20 international system of electrode placement was used. ECG (1 channel) was recorded with one electrode placed over each wrist. Seizures were identified by characteristic ictal EEG. Baseline ECG rates were determined for 10 to 20 second epochs and expressed as beats per minute. Maximum and minimum heart rates during seizures were similarly identified and the difference to the baseline expressed as a percentage. Maximum/minimum heart rate responses were divided into four types: (1) >10% decrease, (2) -10% to +20% change, (3) 20–50% increase, (4) > 50% increase, in heart rate. To enable comparison with other studies, a second scoring system was also calculated were more than 10 beats per minute (bpm) increase was graded as tachycardia and slowing of more than 10 bpm as bradycardia. The type and magnitude of observed change in heart rate was compared to the side of the electroencephalographic seizure onset.

Results

37 partial seizures from 37 patients (one seizure per patient) were analyzed. There were 20 males and 17 females with a mean age of 44 years (range: 18–80 years). 31 were Chinese, 5 were Malay and 1 was Indian. EEG seizures originated from fronto-temporal region and lasted 20 and 150 seconds. 18 seizures were left hemisphere (LH), 13 were right hemisphere (RH) and 6 were bilateral (BL) in onset.

Characteristics of the ictal heart rate changes expressed in percentages are shown in Table 1. Table 2 displays the results expressed as changes of beats per minute. Increases in heart rate usually occurred in the first 10–30 seconds of the seizure, but could also precede, coincide or rarely follow the start of the electroencephalographic seizure. Onset of bradycardia also occurred early after onset (10–30 seconds) of ictal discharges. In one patient, bradycardia was followed by mild tachycardia. None of the patients with bradycardia had preceding tachycardia. Maximum absolute increase in heart rate was from a baseline 54 bpm to 132 bpm in a Chinese 38 year-old male.

All increases and decreases in heart rate were sinus apart from one asystole. In the latter, an ictal event lasting 44 seconds was recorded, over the left mid-anterior temporal region. About 10 seconds after onset of the left temporal epileptiform discharge, bradycardia developed with asystole lasting 6 seconds, punctuated by a ventricular beat, followed by another period of 12 seconds of asystole. Subsequently, the bradyarrhythmia returned, continued for a further 20 seconds and abruptly ended with termination of the seizure [11]. Cardiac evaluation with 24-hour Holter monitoring did not reveal any evidence of cardiac arrhythmia.

Table 3 compares the mean age of patients between the four groups of heart rate responses.

Discussion

Different mechanisms are implicated in the generation of ictal heart rate changes. Increased adrenergic activity during seizures has been observed in animals [12] and may account for ictal tachyarrhythmias being much more common than bradyarrhythmias. Attempts at explaining ictal bradycardia frequently use a more anatomical approach by suggesting that epileptiform discharges may directly stimulate discrete cerebral loci, which influence cardiac rate and rhythm [5–10].

Table 1: Types of ictal heart rate changes compared to the side of ictal discharge

Magnitude of heart rate change		Percentage of patients with change %	n	Side of ictal discharge Left	Right	Bilateral
>-10%	(Type 1)	16	6	3	3	-
-10% to +20%	(Type 2)	51	19	9	7	3
+20% to +50%	(Type 3)	22	8	6	2	-
> +50%	(Type 4)	11	4	-	1	3
Total		100	37	18	13	6

Table 2: Ictal heart rate changes expressed as an increase or decrease of 10 beats per minute

Change in heart rate	%	n	Side of ictal discharge		
			Left	Right	Bilateral
Increase by 10 bpm or more	43	16	8	5	3
Decrease by 10 bpm or more	16	6	3	3	0
No change	41	15	7	5	3
Total	100	37	18	13	6

bpm = beats per minute

Table 3: Mean age and age range of heart rate response types

Heart Rate Response Type	Mean Age	Age Range
Type 1 (> 10% decrease)	44	21–69
Type 2 (-10%–20% change)	54	19–80
Type 3 (20–50% increase)	43	23–78
Type 4 (> 50% increase)	30	22–44

Studies on the incidence of ictal heart rate changes report tachycardia in over 90% of partial seizures depending on the criteria used for tachycardia [1–4]. The comparatively low rate of tachycardia in our study is not readily explained. Methodological differences in definition and quantification of tachycardia may play a role. However all studies use maximum/minimum heart rate changes only, so making this a less likely explanation. A more plausible explanation may be due to the inaccurate cerebral localization of scalp EEG [9]. Based on EEG data, we are not able to accurately differentiate between the proportion of seizures due to temporal or frontal lobe seizures. A high proportion of frontal seizures could possibly account for the low incidence of tachycardia [9]. Other factors such as differing extent and speed of ictal spread between the compared groups of seizures may additionally explain this result.

It may also be worth considering that ethnicity may play a role in the regulation of ictal heart rate changes considering the rate of bradycardia amongst our group is similar to that of the literature [4,9]. However, this can only be considered, if the above-mentioned and several further confounding factors that may influence ictal heart rate responses are excluded. The most important factors that are known to influence the cardiac response to sympathetic stimuli are age, presence or absence of cardiac disease, autonomic neuropathy and possibly antiepileptic medication. Our data (table 3) confirms that increasing age dampens the tachycardic but not bradycardic responses of partial seizures.

Table 4: Comparison of the literature studying heart rate changes during partial seizures

Reference	Number of Seizures	Gender ratio	Mean Age (years)	Seizure Lateralisation	Tachycardia %	Bradycardia %
Current study	37	20 M:17F	44 (18–80)	13 R, 18L, 6BL	43	16
12	47	11 M: 6 F	32 (18–43)	N.A.	91	10
2	67	15 M: 11 F	33 (14–75)	21 R, 21 L, 24 BL	92*	36*
5	36	23 M: 13	38 (1–78)	15 R, 16L, 5BL	95	17
10	127	N.A.	N.A.	38 R, 43 L, 46 others #	82.5	3.3

R = Right Hemisphere, L = Left Hemisphere, BL = Bilateral N.A.= Data not available * No clear definition of heart rate change is provided # 39 of the seizures were frontal lobe, 3 of occipital and 4 of parietal lobe origin, lateralisation was not stated. Tachycardia is defined as an increase of 10 bpm or more. Bradycardia is defined as a decrease of 10 bpm or more.

Different study design and methodology do not allow for comparison of this patient characteristic across studies. However some limited comparisons can be made across the published studies. Studies in references [1–4,12] were conducted in tertiary neurological referral centres with comparable age ranges, gender proportions, location of epileptogenic foci as well as causes of epilepsy. Table 4 compares the major features of studies found in the literature where more than 30 EEG seizures were analysed. Differences in the proportion of patients treated with antiepileptics, corresponding serum levels of antiepileptics and accurate information on accompanying heart disease cannot be assessed across the studies, as these were not analysed or mentioned. Nevertheless, seizure lateralisation, with the exception that tachycardias were more often accompanied by bilateral discharges, bore no effect on heart rate changes. Although the number of patients with bilateral discharges was low, this observation would support the notion introduced by Epstein [14] that heart rate increases primarily depend on the volume of cerebral tissue recruited into a seizure.

Other factors that need to be considered include differences in sinus node innervation and side effects of antiepileptic medication, although to date there is little supporting evidence supporting the latter [1]. To address this, prospective studies with accurate assessment of ictal localization, spread, volume of brain tissue discharging as well as serum anti-epileptic levels will be needed.

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