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The Utility of Head Up Tilt Test with Video Electroencephalography in Children with Recurrent Loss of Consciousness

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Abstract ***Aim:*** We aimed to detect the utility of head up tilt test with video electroencephalography (EEG) in children with unexplained, recurrent loss of consciousness episodes. ***Method:*** Video EEG were recorded during the head up tilt test. The test was terminated if syncope or presyncope with 30% decrease in heart rate and/or systolic blood pressure occurred. Regarding encephalography, average amplitudes and frequencies at the baseline, tilt up position, presyncope, syncope and post-syncope period were evaluated from frontal, temporal and parieto-occipital areas. ***Results:*** There were 29 children (23 girl, 6 boy), with a mean age 13.83±3.3 years who had at least two syncopal attacks. Head up tilt test combined with video EEG was diagnostic in 12/29 patient (41.4%). 8/12 of the patients developed syncope attack and 4/12 of the patients developed presyncope attacks. Four (33.3%) of the patients with syncope attack had associated involuntary movements (3 vasodepressor, 1 mixed type). In the tilt positive group, there were significant differences in the amplitudes of frontal regions between the baseline and presyncope period (p=0.016 and 0.027, right and left hemispheres, respectively). There were also significant differences in the amplitudes of frontal and parieto-occipital regions and in the frequencies involving the bilateral parieto-occipital regions of the baseline and syncope period ($p<0.05$). In conclusion, head up tilt test with video electroencephalography is a useful evaluation for children with recurrent vasovagal syncopes and allows systematic description of electroencephalographic abnormalities during the presyncopal or syncopal events.

Key words Children; Epilepsy; Head up tilt test; Vasovagal syncope; Video electroencephalography

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Introduction

The prevelance rate of epilepsy in general pediatric population is 0.5%.[1] Epilepsy diagnosis is usually made on the basis of history and interictal electroencephalography (EEG) findings. The diagnostic value of the interictal EEG is low. The preferred diagnostic method to distinguish non-epileptic disorders from epilepsy by the ictal records is video EEG.[2] However, it is difficult to obtain a suitable period, like epileptic seizure, loss of consciousness and concomitant movement disorders. It was found that 23-39% of the patients with a diagnosis of epilepsy have been misdiagnosed.[1,3] Tics, staring, syncope, dystonia, gastro-oesophageal reflux, paroxysmal torticollis, alternating hemiplegia, and psychogenic seizures may be misdiagnosed

as epilepsy.[4] King et al reported a study of first seizure presentation and they showed that 36% of the patients did not have epilepsy and 41% of them had syncope.[5]

Syncope is a sudden transient loss of consciousness associated with an inability to maintain postural tone. Syncope among children is very common and approximately one in five children experience an episode of syncope before the age of 15 years.[6] Syncope can result from many different etiologic causes, neurocardiogenic syncope, neurologic and/or psychologic disorders, cardiac, respiratory, toxicologic and metabolic problems. If concomitant motor activity occur, suspicions of epilepsy arise.[7] Limb jerkings could be seen in approximately 50% of the syncopal attacks.[8] History of the recurrent loss of consciousness and accompanied clonic or tonic movements in extremities usually lead to misdiagnosis of epilepsy in children.[9]

The head up tilt test (HUTT) is a useful and effective method on the basis of reproduction of the symptoms and signs of previous syncopal episodes for the diagnosis of vasovagal syncope.[10,11] However, that cannot easily distinguish convulsive syncope from epileptic seizure or psychogenic syncope. Convulsive movements occurring in syncope are not epileptic as demonstrated by the EEG tracing recorded during the episode: progressive slowing until the appearance of middle or high delta waves, generalised and synchronous, or delta waves suddenly followed by transient flattening of EEG activity.[12]

In this study, we aimed to detect the utility of HUTT with video EEG in children with unexplained, recurrent loss of consciousness episodes.

Methods

Twenty-nine patients who had at least two syncopal attacks were evaluated with HUTT between June 2010 and December 2011. Patients were included in the study, if complete neurologic and cardiologic examination, electrocardiogram, routine EEG, chest X-ray, echocardiography (ECHO) revealed no abnormality. No patient was taking any cardioactive, vasoactive or antiepileptic medications at the time of HUTT. None of the patients had an epileptiform activity on interictal EEG or obstructive cardiac pathology on ECHO. Parents were informed and their consent was obtained before HUTT was performed.

Head Up Tilt Test

The patients were positioned at an angle of 70^{o} from the horizontal plane after allowing them to rest in supine position for 30 minutes. Patients were connected to a standard three lead cardiac monitor for continuous recording of heart rate and rhythm throughout the test. An intravenous catheter was placed before starting the test. No intravenous fluid infusions or pharmacological provocation was used during the HUTT. A manual sphygmomanometer of appropriate size was used for blood pressure measurements in 5-min intervals. The test was accepted positive and terminated if syncope or presyncope with 30% decrease in heart rate and/or systolic blood pressure occurred. If no symptoms were observed, the test was ended after 60 minutes. Vasodepressor response was defined as at least 30% decrease in systolic blood pressure, and cardioinhibitory response as an abrupt decrease of at least 30% in heart rate. The mixed pattern response was characterised by both blood pressure and heart rate decreases. The type of response was noted.

Video Electroencephalography Monitoring

Digitised video EEGs, recorded during the HUTT with 20 electrodes and electrodes placed according to the international 10-20 system. The EEGs were recorded by using a Nihon-Kohden, Neurofax EEG-1000 version 05-73, with a sampling rate of 200 Hz. All EEGs were evaluated by a single child neurologist who were blinded to the clinical and diagnostic information of the patients. Seizure like activities were noted.

Collection of Data

The baseline heart rate and blood pressure measurements were taken when the patient was in supine position after a period of 30 minutes rest. The blood pressure was measured using a manual sphygmomanometer and the heart rate was simultaneously noted from the three-lead monitor. Then the tilt position was obtained. The blood pressure and heart rate data were noted every 5 minutes if no symptoms were observed, or more frequently, as mentioned in the tilt protocol, if symptoms like nausea and dizziness were observed. The final heart rate and blood pressure were considered as the values at the time of syncope or presyncope, or at the end of 60 minutes in tilt negative patients.

Documentation of EEG findings included baseline background activity and the presence of EEG changes

during patient events, background slowing, EEG suppression and epileptiform activity. Regarding video EEG, average amplitudes and frequencies at the baseline, tilt up position, presyncope, syncope and post-syncope period were evaluated from frontal, temporal and parieto-occipital areas (Figure 1). Documentation of video findings included the time of consciousness from the head up position, tonic and/or clonic movements and duration of the loss of consciousness.

The study was approved by the local ethic committee of Dokuz Eylul University Medicine Faculty in Izmir.

Statistical Methods

Data were analysed with Statistical Package for the Social Sciences (SPSS), Version 15.0. Means were calculated for continuous variables and the frequency was measured for categorical variables. Comparisons were made by Kruskal-Wallis, Mann-Whitney U and Wilcoxon signed-rank tests. Correlations between groups were evaluated by Spearman correlation test. A p-value <0.05 was considered statistically significant.

Results

There were 29 children (23 girl, 6 boy), with a mean age of 13.83±3.3 year. Tilt combined with video EEG was diagnostic in 12/29 patient (41.4%). 8/12 of the patients developed syncope attack and 4/12 of the patients developed presyncope attacks. Four (33.3%) of the patients with syncope attack had associated involuntary movements (3 vasodepressor, 1 mixed type). Syncopal attacks were cardioinhibitory in 1 of 12 (8.3%), vasodepressor in 4 of 12 (33.3%), mixed type in 6 of 12 (50%) and psychogenic in 1 of 12 (8.3%). All patients with a negative head-up tilt testing showed normal EEG. The initial normal electroencephalography pattern was followed by a diffuse generalised slow high amplitude brain activity at the syncope period. In the tilt positive group, comparisons of average amplitudes and frequencies at the baseline, tilt up position and post-syncope period showed no significant differences. There were significant differences in the amplitudes of frontal regions between the baseline and presyncope period (p=0.016 and 0.027, right and left

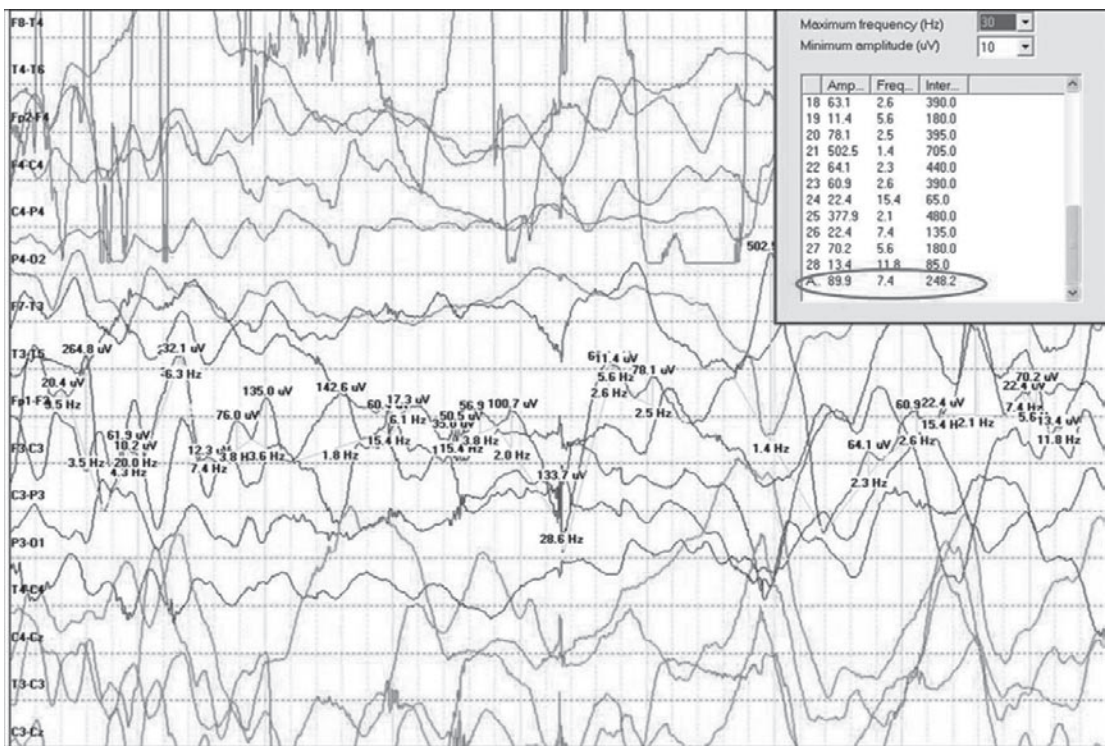

Figure 1 Average amplitudes and frequencies measurement in the syncope period from left frontal region.

hemispheres, respectively) (Table 1). There were also significant differences in the amplitudes of frontal and parieto-occipital regions and in the frequencies of the bilateral parieto-occipital regions in the baseline and syncope period ($p<0.05$) (Tables 2 & 3). Mean total duration of consciousness in vasodepressor, cardioinhibitory and mixed type syncopes were, 59±1.4, 29 and 35.3±25.2 seconds, respectively. Mean duration of EEG abnormalities at the moment of syncope in vasodepressor, cardioinhibitory and mixed type syncopes were 87±4.2, 38 and 64±38.7 seconds, respectively.

Discussion

Vasovagal syncope is the most frequent cause of the recurrent loss of consciousness and usually associated with involuntary, seizure like activities.[13,14] Due to the concomitant clonic or tonic movements, vasovagal syncope may be misdiagnosed as epileptic seizures.[10] Eiris-Punal et al reported nine children which were previously diagnosed as intractable epilepsy but whose HUTT were positive and diagnosed as vasovagal syncope.[10] Song et al reported 13 patients diagnosed as vasovagal syncope with seizure like

Table 1 Average amplitudes of frontal, temporal and parieto-occipital regions in the baseline and presyncope period

Average amplitudes (μV)	Baseline	Presyncope	*p*
Right frontal regions	18.1±2.62	22.54±5.32	0.016
Left frontal regions	18.43±2.93	24.53±7.98	0.027
Right temporal regions	13.56±2.80	15.53±4.05	0.071
Left temporal regions	13.81±3.13	15.30±3.17	0.145
Right parieto-occipital regions	15.7±4.38	18.14±6.30	0.229
Left parieto-occipital regions	15.40±5.49	17.46±3.48	0.224

Table 2 Average amplitudes of frontal, temporal and parieto-occipital regions in the baseline and syncope period

Average amplitudes (μV)	Baseline	Syncope	*p*
Right frontal regions	18.37±2.75	69.61±50.64	0.038
Left frontal regions	18.97±2.81	69.67±47.58	0.027
Right temporal regions	13,76±3.63	64.74±92.44	0.208
Left temporal regions	13.70±3.97	37.31±30.74	0.105
Right parieto-occipital regions	16.64±5.56	31.69±11.94	0.019
Left parieto-occipital regions	16.90±6.97	33.73±12.11	0.026

Table 3 Average frequencies of the frontal, temporal and parieto-occipital regions in the baseline and syncope period

Average frequencies (Hz)	Baseline	Syncope	*p*
Right frontal regions	14.40±3.46	9.67±3.72	0.079
Left frontal regions	13.01±3.62	8.93±3.46	0.155
Right temporal regions	13.57±2.83	14.41±7.91	0.808
Left temporal regions	13.96±2.25	15.68±2.71	0.095
Right parieto-occipital regions	12.53±1.48	8.20±3.25	0.004
Left parieto-occipital regions	13.14±1.79	8.99±4.13	0.048

body movements and they concluded that seizure like activities during vasovagal syncope may not be related to the severity of the syncopal episodes.[14] Edfors et al reported that 45% of the patients previously diagnosed with epilepsy were found to be misdiagnosed by the HUTT.[7]

Head up tilt table test is a method for provoking vasodepressor or cardioinhibitory responses in patients with recurrent loss of consciousness. A sudden decrease in patient's blood pressure without any decrease in heart rate is described as vasodepressor response. On the other hand, significant decrease in the patient's hearth rate or even asystole is described as cardioinhibitory. If a patient have a marked decrease in hearth rate and also with blood pressure it is usually called a mixed response.[15] HUTT can be successfully performed in children from the age of six years. However there is no standardised protocol for the duration or degree of the tilt and whether or not provocation drugs are given.[6] Increasing the tilt angle may also reduce the test specificity. Most studies suggest that HUTT, at angles 60-70° in absence of pharmacological provocation, exhibits high specificity.[11] Haq et al concluded that tilt table testing in children, confirms the diagnosis and avoids unnecessary investigations.[15] In our study protocol we performed the degree of 70° and duration of 60 minutes. The test was diagnostic in 12/29 patient (41.4%). Syncopal episodes were classified according to the literature as cardioinhibitory in 1 of 12 (8.3%), vasodepressor in 4 of 12 (33.3%), mixed type in 6 of 12 (50%) and psychogenic in 1 of 12 (8.3%).[16]

By the time of syncope, hypotension and/or bradycardia may impair cerebral blood flow and induce loss of consciousness and postural tone.[17,18] EEG is very sensitive to decreased cerebral blood flow, by the time loss of consciousness occurs. Head up tilt test with video electroencephalography allows assessment of the concomitant neurological function and cerebral status.[19] Grubb et al performed head up tilt test with continuous EEG monitoring in patients with recurrent loss of consciousness and they reported that in patients with convulsive syncope the EEG showed generalised brain wave slowing, but no epileptiform activity.[20] In previous studies, generalised high amplitudes, delta and theta wave and background suppression during presyncope and syncope period induced by HUTT were reported.[19,21] By the restoration of cardiac rhythm and blood pressure, EEG abnormalities return to normal values in a few seconds.[19] In our study, the initial normal electroencephalography pattern was followed by a diffuse generalised slow high amplitude brain activity at the syncope period and abnormal movements following loss of consciousness were not associated with epileptiform discharges on video EEG. 4/12 (33.3%) of our patients had associated involuntary movements, including tonic and clonic movements, which were accompanied by generalised high amplitude delta slowing. In one patient the diagnosis of psychogenic event was satisfied by the video EEG combined HUTT who experienced unresponsiveness and loss of tone, without any epileptiform or non-epileptiform EEG abnormalities. Regarding video EEG, average amplitudes and frequencies at the baseline, tilt up position, presyncope, syncope and post-syncope period were evaluated from frontal, temporal and parieto-occipital areas. There were significant differences in the amplitudes of frontal regions between the baseline and presyncope period. There were also significant differences in the amplitudes of frontal and parieto-occipital regions and in the frequencies of the bilateral parieto-occipital regions in the baseline and syncope period. Joo et al performed brain single photon emission computed tomography (SPECT) to the patients with vasovagal syncope and compared the results with those of age and sex matched healthy volunteers. They reported that SPECT images showed significantly decreased blood flow in the right anterior insular cortex, left parahippocampal gyrus, bilateral fusiform gyri, bilateral middle and inferior temporal gyri, left lingual gyrus, bilateral precuneus and bilateral posterior lobes of cerebellum in patients with syncope.[22] Lagi et al reported a significant decrease in cerebral blood flow velocity and increase in cerebrovascular resistance in patients with vasovagal syncope.[23] Although we could not detect EEG abnormalities in temporal regions, we suggest that EEG abnormalities that we detect in frontal and parieto-occipital regions reflect the decrease in the cerebral blood flow. Ammirati et al concluded that cardioinhibitory syncope was found to be associated with a longer duration of syncope.[19] In our study group, in contrast with previous reports, mean total duration of loss of consciousness in vasodepressor syncope was found to be longer than in cardioinhibitory and mixed types. Consistently, mean duration of EEG abnormalities at the period of syncope in vasodepressor syncope was longer than the other types.

In conclusion, misdiagnosis of epilepsy is common in patients with recurrent loss of consciousness. Head up tilt test with video electroencephalography is useful in children and allows systematic description of electrocerebral abnormalities during the loss of consciousness.

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