Original Article

Effect of hyperventilation on electroencephalographic activity

Shoaib Rasheed Siddiqui, Azra Zafar, Farrukh Shohab Khan, Musarrat Shaheen
Department of Neurology, Liaquat National Hospital, Karachi.

Abstract

Objective: To observe the effect of voluntary hyperventilation on electroencephalographic activity during routine EEG recording on patients referred to a tertiary care hospital.

Methods: This was an observational study conducted at Neurophysiology Lab, Department of Neurology at Liaquat National Hospital, Karachi from May 2007 to September 2007. Data of 326 patients was collected prospectively and analyzed by SPSS version 10.0. At least 3 minutes voluntary hyperventilation was performed by the subjects. All those patients who were able to perform voluntary hyperventilation adequately were included in the study.

Results: Of 326 recordings, 256 (78.8%) were normal and 69 (21.2%) were abnormal. Focal epileptiform discharges were identified in 8.6% and generalized in 8.3% of subjects. Physiological slowing was found in 31 records. Out of 55 epileptics, 3 had discharges only during HV and 9 had increase in epileptiform discharges.

Conclusion: Hyperventilation has significant effect on background rhythm during EEG recording. It is a useful activation method utilized to increase the yield of EEG.

Keywords: Electroencephalography, Hyperventilation, Epilepsy, Epileptiform, Discharges, Karachi (JPMA 61:850; 2011).

Introduction

Epilepsy is a common problem in Pakistan. Estimated prevalence of epilepsy in Pakistan is 9.9 per 1000 population. It is more prevalent in rural population and the majority of people are treated inadequately or inappropriately.[1]

The EEG is the most common neurodiagnostic test performed to evaluate the patients with suspected seizures. It is not possible always to record the usual event during a routine EEG. Therefore, several activation techniques have been used in clinical EEG to help increase the occurrence of interictal epileptiform abnormalities, which include hyperventilation, intermittent photic stimulation, sleep, and sleep deprivation.[2]

Voluntary hyperventilation (HV) has been implicated as a mean to provoke epileptic seizures since the phenomenon was first described in 1924.[3]

HV constitutes a classic activation procedure of the EEG that usually provokes physiologic slowing of the brain rhythm, more intense and abrupt in children from 8-12 years age. Although the effect can be observed in normal individuals, including children,[4] it is however, more prevalent and pronounced in patients with epilepsy.[5]

In addition to physiological response, HV may activate interictal discharges and seizures in epileptic patients, provoking 3 Hz spike and wave complexes (SWCs) in ~80% of patients with idiopathic generalized epilepsies,[6] and slow spike and wave complexes (SSWCs) in < 50% of those with symptomatic generalized epilepsiesa.[7]

Studies have reported that HV may elicit clinical seizures in as many as one half of patients with absence[8,9] and in 11-25% of individuals with partial seizures.[9,10]

The normal EEG changes associated with HV in children vary widely, and some children demonstrate high amplitude rhythmic slowing. At times the episodes of HV induced high amplitude rhythmical slowing (HIHARS) may demonstrate altered awareness, which prompted speculation

that these episodes may be epileptic.[11] However, the episodes of HIHARS with altered awareness resolve spontaneously in most patients, and it is generally considered that these episodes are not epileptic.[12]

Apart from generalized epilepsies, HV can be effective in other types of epilepsies, including focal epilepsies, where positive activation is obtained in 6-9% of the individuals.[13]

Hyperventilation is a very useful routine technique is Epilepsy Monitoring Units to induce seizures in different types of epilepsies and has been reported to induce psychogenic seizures as well as during daily hyperventilation in upto 33% patients.[14]

This study was carried out to identify the effects of HV on brain activity during routine EEG recording. To the best of our knowledge, no local study in Pakistan on this subject has been published.

Patients and Methods

This is a non-comparative cross sectional study, carried out in neurophysiology laboratory of Liaquat National Hospital, Karachi. Data of 326 patients referred for routine EEG was collected prospectively. All those patients who were able to perform voluntary hyperventilation adequately were included in the study. Those patients who were unable to perform voluntary hyperventilation either because of age or underlying serious medical illness were excluded. Standard EEG recording was done with the placement of 21 scalp electrodes according to the international 10-20 system. Filter was set at 60 Hz, longitudinal bipolar montage was used and paper speed was 30 mm/sec. Subjects were instructed to take deep breaths for at least 3 minutes and chest movements were observed by the technologist present during recording. EEGs were interpreted by certified neurologists, who were unaware of the study and were formally trained in clinical neurophysiology. The effect of HV was defined as unremarkable if no change in brain rhythm was identified and remarkable if any of the following was found i.e., physiological slowing, increase in frequency of epileptiform discharges as compared to rest of EEG recording and detection of epileptiform discharges during HV only.

Data was analyzed by SPSS version 10.0. Relevant descriptive statistics, frequency and percentage were computed for different effects of hyperventilation (i.e. unremarkable and remarkable) described above. Mean and standard deviation were computed for age. Chi-square test was used to identify the overall effect of HV on brain rhythm with 0.05 level of significance.

Results

EEG records of 326 patients were analysed.49.5% were male and 50.5% were female. Mean age was 22.12±12.79 years.

Out of 326 records, 256(78.8 %) were normal and 69 (21.2%) were abnormal. Of abnormal findings were partial epileptiform discharges, generalized epileptiform discharges, diffuse neuronal dysfunction and focal slowing or attenuation suggestive of structural pathology (Figure).

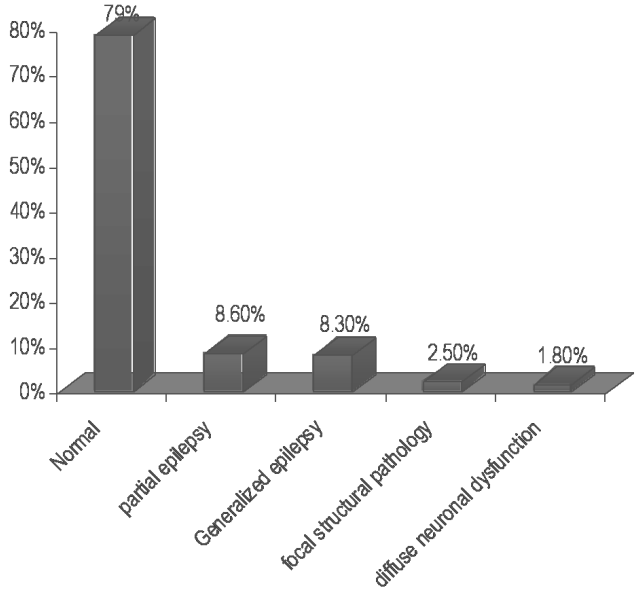

Figure: Description of EEG records included in the study.

Effect of HV was unremarkable in 282 (86.8%) subjects. Out of 43 records, who had remarkable changes, 31 had physiological slowing, 9 had increase in epileptiform discharges and 3 had discharges only during hyperventilation.

Two had absence of seizures and one had focal epileptic discharges. Increase in frequency of epileptiform discharges was identified in 9 (16.3%) out of 55 records. The overall effect of voluntary hyperventilation on rhythmical brain activity was found significant ($p = 0.001$).

Discussion

In our study, the effect of HV on rhythmical brain activity during routine EEG recording was found significant. ($p=0.001$).

Remarkable effects were physiological slowing, increase in frequency of epileptiform discharges as compared to rest of the EEG recording and detection of epileptiform discharges during HV only. The effect was particularly

significant for 3 Hz, spike and wave discharges seen in absence of seizures. In this study, three patients were identified to have absence of seizures on the basis of presence of 3 Hz, spike and wave discharges, two had such discharges only during HV (66.66%). 3 Hz spike and wave complexes were provoked by HV in ~ 80% of patients with generalized idiopathic epilepsies as reported in another study.[5]

Physiological slowing of brain rhythm is a well known effect of HV.[4] It was found in 31 (9.5%) records of our study. The general mechanisms of activation effect of HV are still poorly understood. The hypoxia theory, suggests that the EEG slowing is due to vasoconstriction and diminution of oxygen and dextrose supply to the cerebral cortex.[15]

However, studies have shown that EEG changes are independent of the concentration of inspired oxygen[16] and the reduction of cerebral blood flow.[17]

Increase in epileptiform discharges was seen in 22.2% and 10.71% of the patients with generalized and partial epilepsies respectively. The diagnosis of epilepsy was made on the basis of history and was supported by the presence of epileptiform discharges during EEG recording. This frequency was more as compared to one recently published study.[18] Furthermore, 3.5% patients with partial epilepsy and 7.4% with generalized epilepsies had discharges only during HV. Overall effect of HV was remarkable in 29.62% patients with generalized and 14.28% focal epilepsies. Effect of HV on focal epilepsy was more than reported in other studies[19] in which positive activation was found in 6-9% of the individuals with focal epilepsies. In another study on focal seizures, 29.5% of patients with temporal lobe epilepsies (TLE) and 31.7% of those with mesial temporal sclerosis were activated by HV. HV was considered as an important and simple procedure for seizure activation, especially in cases of TLE. It did not increase the duration of the seizure or the risk of generalization and is a safe method.[20]

Hyperventilation is a useful activation method during routine EEG recording which helps in increasing the yield of EEG. Hyperventilation may also be helpful in recording seizures in situations where the patients are on tapering dose of AEDS as this increases the effects of hyperventilation.[21] Apart from physiological slowing of brain rhythm, it has positive activation effects in both generalized as well as partial epilepsies. However, generalized epileptiform discharges, particularly 3 Hz spike and wave complexes of absence epilepsies are more likely to be activated than partial epileptiform discharges.

Conclusion

Hyperventilation has significant effect on brain rhythmical activity. It is a useful activation method during routine EEG recording to increase the yield of epileptiform discharges in generalized as well as partial epilepsies.

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