

# The Electroencephalogram Changes in Migraineurs

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## SUMMARY

Migraine is associated with a variety of electroencephalographic (EEG) changes. Previous studies using analogue EEG and old diagnostic criteria may under or over report the prevalence of EEG changes in migraine. The objective of this study was to reevaluate the EEG changes in migraine patients diagnosed by applying the new International Classification of Headache Disorder –2 criteria. This was a case control study involving 70 migraine patients and 70 age and gender matched control who were subjected to scalp EEG. The EEG changes during hyperventilation (HV), which were significantly more common in the migraine group were theta activity (34 vs 22,  $p=0.038$ ) and frontal intermittent rhythmic delta activity (FIRDA) (10 vs 3,  $p=0.042$ ). Applying the new ICHD –2 diagnostic criteria and digital EEG, this study yielded previously unrecognized features including FIRDA during HV on EEG.

## KEY WORDS:

*Migraine, Electroencephalography*

## INTRODUCTION

Migraine is a common, debilitating disorder that imposes a large personal burden on sufferers and high economic costs on society. Sufferers have a significant level of migraine-related disability in all aspects of their daily lives, including employment, household work and non-work activities. Since there is a wide range of disorders that cause headache, a systematic approach to classification and diagnosis is an essential prelude to clinical management and to useful research. The International Headache Society published the first set of criteria for the classification of headache disorders in 1988. The introduction of the second edition of the International Classification of Headache Disorders<sup>1</sup> is a major advance in the classification and diagnosis of headache disorders. It provides valuable impact on the clinical diagnosis of headache disorders thereby improving patient management.

The electroencephalogram (EEG) was frequently used in the examination of patients with migraine before the era of neuroimaging. The findings which were reported in migraine previously include focal slow activity, spike activity, posterior quadrant slow wave abnormality, generalized slow activity, low amplitude record and exaggerated hyperventilation response. These electroclinical studies in migraine however

were based on old diagnostic criteria and analogue EEG. Owing to evolving diagnostic criterion, the true prevalence of EEG changes in migraine may be under or overrepresented. The purpose of this study was to reevaluate the EEG changes in a clinic-based sample of migraineurs using the new International Classification of Headache Disorders criteria.

## MATERIALS AND METHODS

A total of 70 patients with migraine and 70 age-, sex-, and race-matched controls were included in this study. The patients who fulfill the International Classification of Headache Disorders criteria were recruited from the neurology clinic, National University of Malaysia while those who had coexisting tension-type headache, focal neurological deficit, epilepsy, psychiatric disorders, head injuries and diseases of the ear, nose, throat and dental were excluded. Controls were selected from the community and had no evidence of migraine. They were subjected to standard scalp electroencephalography. The EEG was studied in the awake state at rest, during photic stimulation and during hyperventilation. If patients developed acute migraine they were treated with oral sumatriptan.

Statistical analysis was done by using the SPSS package version 11.0 software and p value of less than 0.05 was deemed statistically significant. Associations between outcome measures (EEG changes are associated with migraine, photic stimulation and hyperventilation) are determined using the chi-square test.

## RESULTS

In the migraine group, the median age was 30 years (Interquartile range 24-40) while in the control group the median age was 31 years (Interquartile range 23-39). The distribution according to gender, ethnic group and education levels are shown in Table I. Out of the 70 patients, 63 (90%) had migraine with aura. There were 27 (38.6%) patients who had a family history of migraine. Thirty-eight (54.3%) patients had migraine for more than ten years. The duration of migraine did not differ significantly between the two genders. Migraine with aura was more common in females (57) than the males (6),  $p < 0.005$ . Women were more as likely as men during HV, but more likely than men during photic stimulation to develop a migraine attack (48 vs 5,  $p=0.011$ ).

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During EEG recording, the incidence of headache during the activation procedures (hyperventilation and photic stimulation) was recorded in (Figure 1). During hyperventilation, 44 (63%) patients developed EEG changes (other than accentuation of alpha rhythm) as compared to 27 (38.6%) in the control group ( $p = 0.004$ ). There were no abnormal EEG changes during photic stimulation in both groups. There was no significant difference in the incidence of an exaggerated response during HV between the two groups (16 vs. 8,  $p = 0.073$ ). Only the presence of theta activity and frontal intermittent rhythmic delta activity (FIRDA) was significantly higher in the migraine group (Table II). Theta transients on EEG was found not to be significantly different among the migraine patients and controls (14 Vs 10,  $p = 0.370$ ). Both the genders were equally likely to develop these EEG changes. During hyperventilation, the number of migraine patients who had headache and concomitant EEG changes did not significantly differ from those who had headache without EEG changes (36 Vs 21,  $p = 0.913$ ). There was no significant difference in the EEG changes between the migraine patients with or without aura (40 Vs 4,  $p = 0.742$ ).

**DISCUSSION**

Electroencephalography (EEG) has traditionally been considered to be useful adjunct to the clinical evaluation of headache. However, EEG is not indicated in the routine evaluation of patients presenting with headache. EEG abnormalities in headache were originally described by Engel *et al*. Weil described paroxysmal high voltage abnormal slow wave activity in a number of patients and proposed the term

dysrhythmic migraine for this group<sup>2,3,4</sup>. Dow and Whitty<sup>3</sup> found that relatives of migrainous subjects also had a high incidence of EEG abnormalities providing circumstantial evidence for a constitutional basis for migraine. Since migraine is likely to be a constitutionally determined disorder, it is of interest to know if the EEG of such patients shows characteristic features.

Of the 70 migraine patients, 63 (90%) had migraine with aura, being commoner in females than males. Previous studies reported only about 20% of migraine headaches were associated with aura. We postulated that this marked discrepancy in the frequency of migraine patients with aura is due to the stricter criteria imposed by the revised ICHD-2 classification. In other words, our study population represented a "purer" sample of migraine patients and non-migraine controls.

Females were more likely to develop headache attacks during PS. The incidence of headache during HV was higher in the migraine than control subjects and this observation is consistent with the known fact that HV and PS are predisposing factors for acute migraine attacks. Unlike previous studies, in our study during PS there were no EEG changes found in both groups. We speculate that in comparison with Western migraineurs, our patients may not be genetically susceptible to intermittent photic stimulation. Several authors have shown abnormalities of various types in the EEG of patients complaining of migraine. The incidence of EEG abnormalities reported above varies from 13-60% depending on the interpretation during HV in migraineurs,

**Table I: Baseline characteristics of migraine patients and their controls**

	Migraine n=70	Control n=70	P value
Age (years)			
Median	30	31	0.979
IQR	24-40	23-39	
Gender			
Females	59 (84.3)	59 (84.3)	NS
Males	11 (15.7)	11 (15.7)	
Ethnic			
Malay	55 (78.6)	55 (78.6)	NS
Chinese	7 (10)	7 (10)	
Indian	8 (11.4)	8 (11.4)	
Education			
Primary	2 (2.9)	0 (22.9)	NS
Secondary	24 (34.3)	16 (22.9)	
Tertiary	44 (62.9)	54 (77.1)	

+ values in parentheses are percentages  
IQR Interquartile range

**Table II: Electroencephalographic changes during hyperventilation**

	Migraine n=70	Control n=70	P value
Theta transients			
Yes	14 (20.0)	10 (14.3)	0.370
No	57 (81.4)	60 (86.0)	
Theta activity			
Yes	34 (48.6)	22 (31.4)	0.38*
No	36 (51.4)	48 (68.6)	
FIRDA			
Yes	10 (14.3)	3 (4.3)	0.042*
No	60 (86.0)	67 (96.0)	

+ values in parentheses are percentages  
IQR Interquartile range

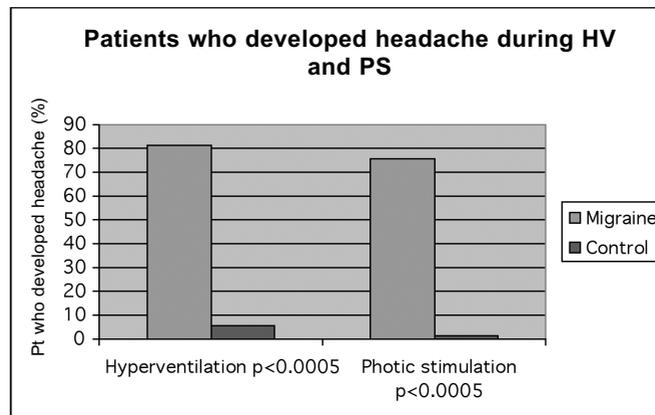


Fig.1: Frequency of patients who develop headache during hyperventilation and photic stimulation

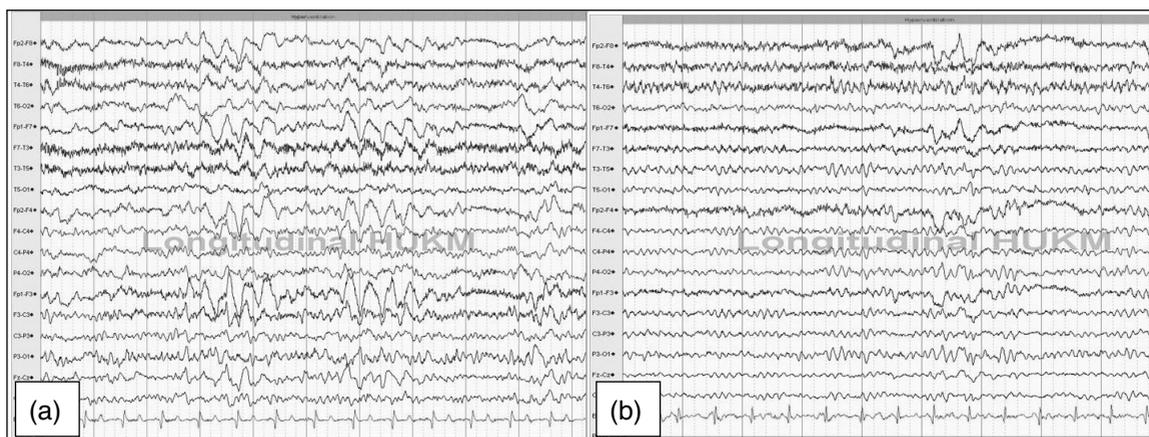


Fig.2: Electroencephalograph depicting (a) frontal intermittent rhythmic delta activity (FIRDA) and (b) theta activity

the diagnostic standards used and the inclusion of mixed conditions<sup>5,6</sup>. The changes that we observed were more profound than previously reported. To date, there have been no publications on a similar study using the new ICHD-2 diagnostic criteria. Previous reports on EEG changes in migraine may be over or under represented. Applying the new ICHD-2 diagnostic criteria we were able to reevaluate the EEG changes in migraine patients.

The EEG abnormalities that were most commonly observed during hyperventilation were theta and frontal intermittent rhythmic (delta) activity (FIRDA). The latter which has been described as bisynchronous slow waves at 2-3 Hz/sec, is classically reported with lesions that directly or indirectly involve the mesencephalon, diencephalon, orbital and nasal surfaces of the frontal lobe. It has also been observed in patients who have metabolic, toxic and endocrine encephalopathies involving the subcortical and cortical cerebral grey matter more than the cerebral white matter, hydrocephalus, cerebral odema, increased intracranial pressure, stroke, deep midline lesions, posterior fossa tumors, third ventricle and pituitary tumors. In two previous studies the occurrence of FIRDA has been reported in acute confusional migraine before the publication of ICHD-2<sup>8,9</sup>. FIRDA in nonconfusional migraine is a new finding that has not been reported in previous studies.

Applying the new ICHD-2 diagnostic criteria and digital EEG, this study yielded previously unrecognized features including FIRDA during HV on EEG. The relationship between FIRDA and migraine is still unknown although both were postulated to have underlying neurovascular theories. The presence of FIRDA in migraine may help to initiate further researches to determine the pathogenesis of these EEG changes in migraine as well as the management and prognosis.

## REFERENCES

- Olsen J, Steiner TJ. The international classification of headache disorders, 2nd edition (ICHD-II). *J Neurol Neurosurg Psychiatr* 2004; 75: 808-11.
- Selby G, Lance JW. Observations on 500 cases of migraine and allied vascular headache. *J Neurol Neurosurg Psychiatr* 1969; 23: 23-32.
- Dow DJ, Whitty CWM. Electroencephalographic changes in migraine. *Lancet* 1947; 2: 52-4.
- Camp WA and Wolff HG. The EEG changes in migraine. *Archives Neurol* 1961; 4: 52.
- Slatter KH. Some clinical and EEG findings in patients with migraine. *Brain* 1968; 91: 85-98.
- Hockaday JM, Whitty CW. Factors determining the electroencephalogram in migraine: a study of 560 patients, according to clinical type of migraine. *Brain* 1969; 92: 769-88.
- Engel GL, Ferris EB, Romano J. Focal electroencephalographic changes during the scotomas of migraine. *Am J Med Sci* 1945; 209: 650-7.
- Hoosmand H. The clinical significance of frontal intermittent rhythmic delta activity (FIRDA). *Clin Electroencephalogr* 1983; 14: 135-7.
- Pietrini V, Terzano MG, D'andrea G, Parrino L, Cananzi AR, Ferro-Milone F. Acute confusional migraine: clinical and electroencephalographic aspects. *Cephalalgia* 1987; 7: 29-37.