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Original Research Article

Comparative study of electroencephalography changes in dementia

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ABSTRACT

Background: Dementia affected about 46 million people in 2015and this number will roughly triple within the next 40 years. In 2011 Alzheimer's Disease International argue that dementia has become one of the most urgent health and social care challenges of the 21st century and its potential effect on economies around the world is attracting global attention. Predicting dementia in the early stages would be essential for better treatment before significant brain damage occurs. Current difficulty is the lack of specific biomarkers. In some previous studies electroencephalography (EEG) have shown the capability to identify dementia early and even classify the degree of its severity at a lower cost for mass screening. The aim and objective of this study was to EEG changes in vascular dementia and Alzheimer's Disease Related Dementias (ADRD) or dementia where no cause is identifiable, to measure severity of dementia by using DSR scale in different subjects and to correlate DSRS with EEG findings.
Methods: Study sample was the 40 patients in each three groups- Dementia patients without any known cause of dementia or Alzheimer's Disease Related Dementias (ADRD), Vascular dementia (VaD) patients and Controls (age and sex matched subjects scoring more than the cut of score on dementia Scale). Written informed consent will be taken after explaining the objectives and procedure of study in detail. EEG were recorded in eyes closed, on intermittent photic stimulation and hyperventilation, only eyes closed data was used in study and these data were entered in excel sheet and analyzed using SPSS Software, appropriate statistical test was applied wherever necessary.
Results: Participants with VaD have theta waves while ADRD group have delta waves preponderance as compare to control.
Conclusions: EEG can have additive value in diagnosing VaD as well as it alone can be helpful in differentiating healthy individuals from dementia patients.

Keywords: Alzheimer's disease, Dementia scale**,** EEG, Vascular dementia

INTRODUCTION

In India about 8% populations is in the elder age group in which 3.6% elderly person have dementia.[1] Of all patients with dementia group of disorders, 50 to 60 percent have Alzheimer's dementia (AD).

Dementia is strongly associated with increasing age, and consequently anticipated to pose significant challenges to public healthcare systems worldwide in the coming decades.[2] Prevalence of dementia is slightly higher in women as compare to men at ages 65 and greater.[3,4] The next common type of dementia is VaD.[5]

Doctors diagnose dementia based on a medical history, a physical examination, laboratory tests, and the characteristic changes in thinking, day-to-day function and behavior. It is harder to determine the exact type of dementia even on many dementias has specific distinguishing features, because the symptoms and brain

changes of different dementias can overlap. Dementia also lack confirmatory test.[6]

EEG has a definite role in evaluating changes in mental states. Temporospatial analysis of the EEG record is a useful indicator of cortical dysfunction in dementia and correlates with the degree of cognitive impairment and also useful in distinguishing patients with dementia from those experiencing normal aging.[7]

EEG measures voltage difference between two electrodes, in many clinical conditions the normal electrical activity of the brain is found to be disturbed. Presently EEG is a considered as nonspecific measure of clinical states in many conditions affecting brain. Still limited numbers of abnormalities can be identified in widely varied disease or mental states. EEG is almost always abnormal in moderate dementia; newer methods are searching to make these finding reproducible in different ways.[7]

The aims and objectives of this study was to EEG changes in vascular dementia and Alzheimer's Disease Related Dementias (ADRD) or dementia where no cause is identifiable, to measure severity of dementia by using DSR scale in different subjects and to correlate DSRS with EEG findings.

METHODS

This was a cross sectional hospital based study to compare the frequency distribution among healthy control and their respective age and sex matched diseased participants. Patients who met the diagnosis of dementia according to diagnostic criteria for research of International classification of diseases -tenth edition (World Health Organization, 1993) and were drug naïve and aged above 55 years were included in the study.

After complete description of the study to the participants, written informed consent was obtained from all participants. A detailed physical examination was done to rule out major medical or neurological illness. Socio-demographic data was collected. After that clinical assessment of all groups was done using DSRS and MMSE scales. EEGs were recorded by departmental set-up.

The International system (IS) 10-20 system was used for electrode placement (with 19 electrodes). Even numbered 2,4,6,8 refer to electrodes placed on the right side of the head, whereas odd numbers 1, 3, 5, 7 refer to electrodes on the left side of head.

Lower the number means electrode placed in more central part of head and the "z" refers to the midline of head. Authors set low pass filter (Lf) at 1 Hz and high pass filter (Hf) at 70 Hz, sensitivity 7.5 µV/mm, Time base 30mm/second, and notch filter at 50 Hz in all recordings. Authors took about 20 minutes recording of each participant while resting with eyes comfortably closed and examine each EEG record in its full length.

In each record authors select 10 seconds of artifacts free page in eyes closed and with the help of this EEG software authors plot frequency distribution for them separately.

The software depicts only 4 types of frequencies i.e. delta (0.5 Hz to 4 Hz), theta (5 Hz to 8 Hz), alpha (9 Hz to 13 Hz) and beta (14Hz to 30 Hz). The frequency of each channels and combined frequency were placed in excel sheets, they are further divided in right and left half as even numbers of electrodes represent right half of head and odd numbers represent left half.

So, even numbers channels frequencies are summed together, and odd channels frequencies summed together. Thus, data from control and VaD participants were prepared in eye closed state, on IPS and on hyperventilation.

RESULTS

The mean age of control group was about 62.1±5.3 years, VaD group was 66.9±9.7 years and ADRD group was 65.4±8.6 years. According to the inclusion criteria minimum age was kept 55 years, in all three groups maximum age was the 85 years in all three groups of participants.

Table 1: Description of age of study participants in three groups.

Statistical parameter	Groups		
Age (in years)	**Control group**	**VaD group**	**ADRD group**
Mean	62.1250	66.9750	65.4750
Median	58.0000	65.0000	65.0000
Standard deviation	5.39795	9.71514	8.62015
Minimum	55.00	55.00	55.00
Maximum	85.00	85.00	85.00

The number of male participants was more in all the groups as compared to female participants. VaD group have highest no. of male participants while ADRD group have highest no. of female participants.

Table 2: Description of gender-wise distribution of study participants in three groups.

Groups		Gender		Total
		Male	**Female**	
Group	Control	27	13	40
	VaD	29	11	40
	ADRD	26	14	40

The combined EEG Findings in eyes closed situation revealed a significant difference between the proportions of delta wave in EEG amongst different groups which was highest in ADRD group.

Significant difference was also observed between the median percent contributed by theta wave in the EEG of three groups, highest in VaD group. The similar were the findings with respect to alpha waves and beta wave. Post Hoc analysis was performed to know the detailed pair-wise comparison. The post Hoc analysis revealed that contribution of Delta wave in the EEG record with eyes closed was significantly greater in ADRD group as compared to VaD group as well as control group.

Table 3: Comparison of combined frequency distribution with eyes closed between control group, VaD group and ADRD group.

EEG waveforms	Control group		VaD group		ADRD group		p value
	Mean rank	Median	Mean rank	Median	Mean rank	Median	
Delta	38.40	23.00	49.81	28.500	93.29	42.0000	0.000*
Theta	39.16	21.00	82.50	36.000	59.84	26.0000	0.000*
Alpha	89.95	34.00	59.45	19.500	32.10	15.0000	0.000*
Beta	77.25	17.50	57.04	14.000	47.21	13.5000	0.000*

*p value <0.05 was considered statistically significant.

Table 4: Post hoc analysis of comparison of combined frequency distribution with eyes closed between control group, VaD group and ADRD group.

Parameter	Groups	p value
Delta	Control vs VaD	0.426
	VaD vs ADRD	0.000*
	ADRD vs control	0.000*
Theta	Control vs VaD	0.000*
	VaD vs ADRD	0.011*
	ADRD vs control	0.023*
Alpha	Control vs VaD	0.000*
	VaD vs ADRD	0.001*
	ADRD vs control	0.000*
Beta	Control vs VaD	0.028*
	VaD vs ADRD	0.617
	ADRD vs control	0.000*

The combined EEG Findings in eyes closed situation revealed a significant difference between the proportions of delta wave in EEG amongst different groups which was highest in ADRD group. Significant difference was also observed between the median percent contributed by theta wave in the EEG of three groups, highest in VaD group. The similar were the findings with respect to alpha waves and beta wave (Table 3).

Post Hoc analysis was performed to know the detailed pair-wise comparison. The post Hoc analysis revealed that contribution of Delta wave in the EEG record with eyes closed was significantly greater in ADRD group as compared to VaD group as well as control group. The Theta wave had significantly lesser contribution in EEG of control group as compared to VaD group and ADRD group. The proportion of theta wave in EEG record of VaD group patients was significantly more as compared to ADRD group. With respect to the alpha wave all groups differed significantly with each other.

The control group significantly showed greater proportion of Alpha wave as compared to that in VaD group and ADRD group. The proportion of alpha wave in EEG record of VaD group patients was significantly more as compared to ADRD group. Only delta wave in control vs VaD and beta wave in VaD vs ADRD did not showed significant differences (Table 4).

The Theta wave had significantly lesser contribution in EEG of control group as compared to VaD group andADRD group. The proportion of theta wave in EEG record of VaD group patients was significantly more as compared to ADRD group. With respect to the alpha wave all groups differed significantly with each other. The control group significantly showed greater proportion of Alpha wave as compared to that in VaD group and ADRD group.

The proportion of alpha wave in EEG record of VaD group patients was significantly more as compared to ADRD group. Only delta wave in control vs VaD and beta wave in VaD vs ADRD did not showed significant differences. In mild VaD group participants alpha waves constitute maximum while in ADRD delta wave constitutes the maximum part.

The slow waves that are combined delta and theta waves value in VaD was 47.05% and 53.67% for the ADRD group. The delta and alpha waves showed significant difference between mild VaD and mild ADRD. In mild VaD group participants alpha waves constitute maximum while in ADRD delta wave constitutes the maximum part. The slow waves that are combined delta and theta

waves value in VaD was 47.05% and 53.67% for the ADRD group. The delta and alpha waves showed significant difference between mild VaD and mild ADRD (Table 5).

Table 5: Different waves' distribution in mild VaD and mild ADRD participant groups and their comparison.

Group	Sample size (n)	Delta Mean±SD	Theta Mean±SD	Alpha Mean±SD	Beta Mean±SD
Mild VaD	8	22.625±8.175	24.4250±7.3860	33.2500±12.69139	19.875±8.1842
Mild ADRD	8	39.125±14.554	26.1250±5.8171	17.8750±7.35697	16.7500±4.652
p value		0.018*	0.428	0.018*	0.561

Table 6: Different waves' distribution in moderate VaD and moderate ADRD participant groups and their comparison.

Group	Sample size (n)	Delta Mean±SD	Theta Mean±SD	Alpha Mean±SD	Beta Mean±SD
Moderate VaD	21	28.181±10.111	38.8636±9.76044	19.0000±5.85540	13.500±4.616
Moderate ADRD	22	43.9545±9.702	28.1364±6.6711	15.0909±4.16229	12.954±5.140
p value		0.000*	0.000*	0.026*	0.689

Except for beta waves all waves in moderate dementia participants showed significant correlation. In moderate VaD participants theta wave distribution was the prominent. While in ADRD group delta wave constitute the maximum distribution. The slow waves in VaD group were 67.04% and in ADRD group was 72.09%. Like the participants in moderate dementia, severe Dementic participant also showed significant correlation in all the three wave forms delta, theta, and alpha. The proportion of slow waves (62.5% in VaD group; 75.3% in ADRD group) was increased as compared to mild dementia participants but as comparison to moderate dementia it was only increased in ADRD group.

VaD group did not showed theta waves preponderance as shown by moderate VaD group.

Table 7. Different wave's distribution in severe VaD and severe ADRD participant groups and their comparison.

Group	Sample size (n)	Delta Mean±SD	Theta Mean±SD	Alpha Mean±SD	Beta Mean±SD
Severe VaD	11	28.300±10.499	34.2000±5.45283	21.4000±7.47143	16.300±6.5498
Severe ADRD	10	49.20±11.4095	26.1000±7.37036	13.0000±4.10961	11.600±4.1419
p value		0.002*	0.015*	0.010*	0.095

Like the participants in moderate dementia, severe Dementic participant also showed significant correlation in all the three wave forms delta, theta, and alpha. The proportion of slow waves (62.5% in VaD group; 75.3% in ADRD group) was increased as compared to mild dementia participants but as comparison to moderate dementia it was only increased in ADRD group. VaD group did not showed theta waves preponderance as shown by moderate VaD group.

DISCUSSION

Many studies have demonstrated association between dementia and EEG changes.[8-12] In this study control group eyes closed EEG recording showed maximum alpha and minimum beta waves, constituting (34% and 17.5% respectively). The EEG of VaD group with eyes closed showed that the maximum portion of EEG was occupied by Theta wave (mean 34%) and minimum by Beta wave (15%). The VaD group showed increase in theta activity as compared to both ADRD and control group as shown by previous studies.[13-15]

Unlike control group and VAD group, the EEG of ADRD group eyes closed showed that the maximum proportion is of Delta wave (44%) and minimum proportion is of Beta wave (27%). In ADRD group majority of contribution were from slower waves i.e. delta and theta (71.6%) which was significantly higher from control

group and VaD group. The delta waves distribution is increased in both AD and VaD participants as comparison to control group. These finding are consistent with the slowing of the EEG in AD patients represented by a larger shift from the alpha frequency band into the slower frequency band when compared to controls.[15-19.]

Some studies showed relationship between education and dementia, i.e. low education was associated with an increased risk for dementia.[20,21] In this study in both groups of diseased participant illiterate were the maximum in number (14 in VaD group and 13 in ADRD group) while only 4 in VaD group and 1 in ADRD group were graduate. This study did not find any correlation between education and dementia. Like this study few other studies also reported no association between education and dementia.[22,23] Author measured the severity of dementia by using DSR scale and divided participants into mild, moderate and severe dementia accordingly. In both diseased participant groups moderate dementia participants were highest in number. In ADRD participants as the severity of dementia increased the distribution of delta waves increased, in VaD participants also slow waves increased but they have higher distribution of theta wave as compare to theta wave in ADRD group. Thus, author found significant correlation between severity of dementia and EEG frequency changes. As the severity increases the EEG changes also deteriorated.[10]

CONCLUSION

By the use of EEG diagnosis of dementia can be made and EEG is capable of differentiating different VaD from other dementias where cause is not known. EEG can also be used in staging and monitoring of different dementias.

Recommendations

EEG offers a number of conveniences in making diagnosis of dementia and also enhances communication between the electroencephalographer, psychiatrist, neurologist and other clinical specialists. The newer techniques do not make the record more specific but merely render it more easily understandable. EEG help can be sought in cases of dementia. Limitation of the study- Difficult to find old age drug naïve participants, stimulating maneuvers were not included, Other dementia types were not included.

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