CEYLON J. MED. SCI. (D) Vol. XII, Pt. 1, (Dec. 1963)

A Study of the Electroencephalographic Changes in Subjects Suffering from Very Severe Anaemia

by

DRS. R. S. WATSON, M.B.B.S., PH.D. (LOND.), M. S. NESARAJAH, M.B.B.S. AND S. A. N. PERERA

Department of Physiology, University of Ceylon.

In our study we were interested to find out whether in cases of very severe anaemia. the electrical activity of the brain showed any significant changes.

It is well known that chronic cerebral anaemia could give rise to neuralgic headache, faintness, giddiness, tinnitus and disinclination for effort. Some cases also show somnolence, mental apathy, depression, anxiety, excitability, hallucinations and delusions. We were also interested in the study as these cases with very low haemoglobin percentages (40%Hb) would serve as useful subjects for the study of the influence (if any) of anaemic anoxia on the electroencephalograms.

Davis, Davis et al (1938) recorded the electroencephalograms of eleven normal men. breathing gas mixtures containing 7·8 to 11·4 percent oxygen. The typical sequence of changes in the E.E.G. was:

1. The average voltage increased slightly and alpha (10/sec.) waves appeared in those records which originally showed none.
2. Alpha voltage decreased, the trains of alpha waves became shorter and the intervals between trains lengthened.
3. Groups of waves at 8 and 7/sec. appeared at the vertex, while 10/sec. waves continued at the occiput.
4. Irregular delta waves (0·25 or longer) appeared at the vertex and almost immediately thereafter at the occiput, alternating with the 10/sec. waves. At this stage slight cyanosis was observed, and subjective changes were first reported.

Hill and Parr (1950) give a fairly comprehensive review of the work done on the influence of anaemic anoxia on the electroencephalogram. Anaemic anoxia may result from deficient oxygen carrying power of the blood. due either to the lack of sufficient haemoglobin or to fixation of the latter, as in carbon-monoxide poisoning. The following is a summary of the findings in cases of anaemic anoxia :—

Slow rhythms have been observed in a few instances of patients with anaemia, but the degree of slow rhythm abnormality seems to depend more on the type of anaemia, than on the haemoglobin value or the red blood cell count. Thus a patient with pernicious anaemia (Hb 7·12 gm/100c.c. and R.B.C. 2,090,000/cu.m.m.) was found to have a generalised abnormality in the E.E.G. of 3-7 cycles/sec. rhythms, of moderate voltage and with or no normal rhythms to be seen; while another patient with severe and chronic anaemia (Hb 2·5 gm/100 c.c. and R.B.C. 630,000/cu.m.m.) had only a mildly abnormal record.

In general, it appears that in many animal species during extreme anoxia, the electrical activity of the cortex is abolished. In man, the studies deal with less severe degrees of anoxia and the more general finding is the appearance of slow rhythms, widespread delta activity being the most abnormal condition observed. In some instances, a slight increase in frequency of cortical rhythms has been noticed, before the onset of slow rhythms or arrythmias.

Meyer et al (1954) studied the E.E.G. changes in 28 cats and 24 monkeys, on nitrogen breathing. They noticed that the E.E.G. showed decreasing amplitude and slowing of fast activity. Further reduction of the oxygen levels, resulted in flattening of the E.E.G. record except for bursts of slow waves similar to the so called pentobarbital bursts. Re-administration of oxygen recapitulated the sequence of changes. They also noticed that when a zone of cortex was rendered totally anoxic, the alpha rhythm disappeared when the oxygen availability had been reduced by 80%. When the vessel was released, slow, low amplitude activity in the E.E.G. reappeared, after 20% increase in oxygen availability. The E.E.G. was restored to normal when the polarograph reading rose to 80%.

Longheed et al (1955) noticed that dogs ventilated with 100% nitrogen do not develop E.E.G. changes for 6–8 minutes when hypothermic, but develop electrical silence quickly at normal body temperature. According to them, the electrical silence is not the result of the anoxia, but of the accumulation of waste products, especially carbon dioxide.

Method

All our 38 subjects were selected from the Colombo Group of Hospitals and consisted of 28 males (age group 25-65 years) and 10 females (age group 19-35 years). Of the 28 males 5 were in the age group of 65-70 years. In our selection of these 38 cases, special care was taken to see that the subjects were not suffering from any other serious disorder that could affect the electroencephalogram. We were mainly concerned with very severe anaemic subjects.

Our main criteria for the selection of very severe anaemic subjects was the haemoglobin percentage of their blood as determined by a photometric method, using the M.R.C. photometer (King et al, 1948). All subjects with haemoglobin percentages of 40 and under were included in our investigation. Of our 38 cases, 9 had a haemoglobin percentage of 16 to 20%; 13 cases 21 to 25%; 2 cases 26 to 30%; 8 cases 31 to 35% and 6 cases of 36 to 40%. The other haematological investigations included the following:— The packed cell volume, the mean corpuscular diameter; the mean corpuscular haemoglobin concentration and the red blood cell count. The more reliable index of the degree of anaemia would be the mean corpuscular haemoglobin concentration. In addition to the above investigations, the oxygen saturation of the blood in the vessels of the ear was determined with the use of a Stanco Oximeter. (Stanley Cox Limited, England). In all our subjects, a complete case history was taken, a general clinical examination was done and this was followed by an E.E.G. examination under identical conditions for each case. For the E.E.G. examination the subject was made to rest on a couch and relax with the eyes closed. The records were taken on an eight channel Grass E.E.G. machine using needle electrodes. and both scalp-to-ear and scalp-to-scalp techniques were used, in all cases. Recordings were made from the frontal, parietal, occipital and temporal areas. Analysis of the records were made by studying the amplitude and frequency of the recordings. As the control group, we used the same 75 (55 males and 20 females) Ceylonese adults drawn from the

Ceylon University, who were used as the controls, for our study of the E.E.G. changes in Ceylonese boxers. (Nesarajah et al, 1961).

Results

The main findings in the 38 cases are tabulated in the table which includes the following data on each case. Age, Sex, Haemoglobin percentage, Red blood cell count, Packed cell volume, Mean corpuscular haemoglobin concentration, E.E.G. findings and the results of oximetry.

In considering the degree of anaemia, we were guided by two main values — the haemoglobin percentage and the mean corpuscular haemoglobin concentration.

The 38 cases selected had haemoglobin percentages less than 40%. On studying these tracings, the most significant change was that in 24 of these cases i.e. 63·2%, a marked diminution in the amplitude of the potentials appeared in most leads. (Fig. I). The amplitude of the potentials was in the region of 5-25 microvolts, with an average value of approximately 10-15 microvolts. It is known that tracings taken from apparently normal individuals may show a marked diminution in amplitude, but the number occurring in a series of controls is never so large. In our controls (75 cases), only eight cases (10·6%) showed a similar fall in the amplitude of the potentials. These diminished amplitude potentials appeared for prolonged periods in most of the leads, unlike the controls.

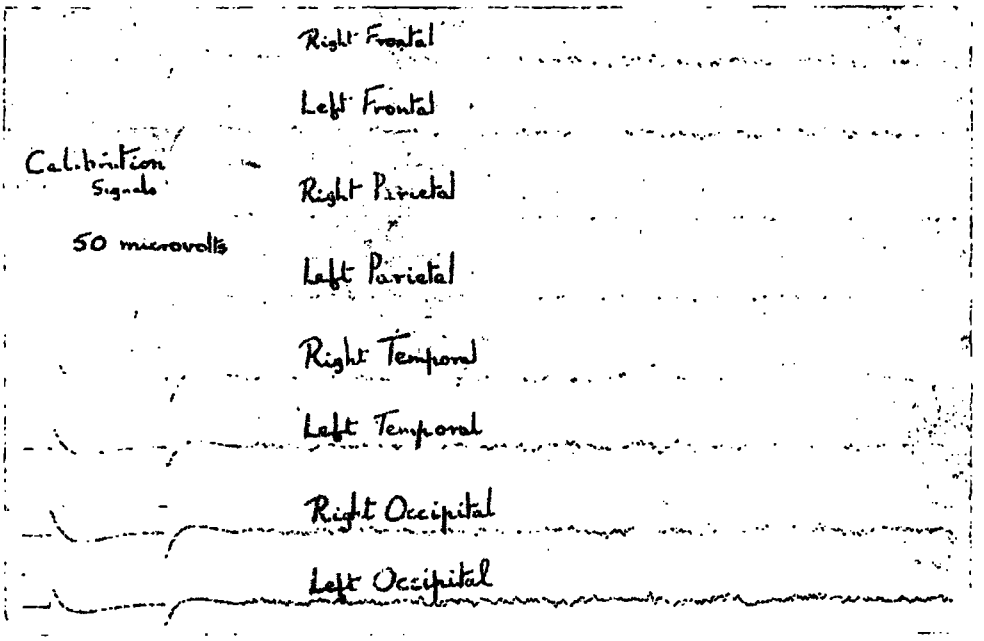

Fig. I. Shows the calibration signals of 50 microvolts, and the marked diminished amplitude potentials in all leads.

Of the 38 cases selected, 33 cases had a mean corpuscular haemoglobin concentration less than 32. Of these 33 cases, 20 cases i.e. 60·6% showed similar diminished amplitude E.E.G. potentials.

These findings seem to suggest some relationship between the E.E.G. patterns and the haemoglobin levels, in the subjects examined. However, it must also be pointed out that 4 out of the 5 cases with M.C.H.C. values in the range of 32-38 also showed diminished amplitude E.E.G. potentials. These latter cases may represent those cases where diminished amplitude potentials would have been recorded, even without the severe anaemia. (just like our 10·6% normal controls)

It is therefore highly probable that in very severe cases of anaemia, there is a significant change in the E.E.G. pattern. It is probable that in these cases of very severe anaemia with low haemoglobin concentrations and diminished number of circulating red blood cells, the biochemical equilibrium inside the neurones is altered, resulting in these changes of electrical activity. It was not possible to follow these cases after suitable treatment, to see the changes (if any) in the E.E.G. after the blood picture was restored to normal limits. These low amplitude potentials may have some relation to the mental apathy and other changes commonly noticed in clinical cases of very severe anaemia. Our findings agree with the findings of Meyer et al (1954) where in cats and monkeys under nitrogen breathing, decreasing amplitude potentials were noticed.

SUMMARY

38 very severe cases of anaemia were examined with a view to studying the influence (if any) of severe anaemia on the E.E.G. changes in the adult. 75 normal adults were used as controls.

24 of the 38 cases (63·2%) showed a significant decline in the amplitude of the E.E.G. potentials as compared to the normals.

It is suggested that E.E.G the changes are probably due to the altered biochemical equilibrium within cerebral neurones and this may be responsible for the clinical changes noticed in these cases of very severe anaemia.

ACKNOWLEDGEMENTS

We were extremely grateful to the Visiting Physicians and Obstetricians of the General Hospital, Colombo, for allowing us to transport these very severe cases of anaemia to the Department of Physiology.

REFERENCES

DAVIS, P. A., DAVIS, H. AND THOMPSON, J. 1938.—Progressive changes in human electroencephalogram under low oxygen tension. *American J. Physiol.*, **123**, 51—52.

HILL, D. AND PARR, G. 1950.—Electroencephalography. Macdonald Press.

KING, E. J., GILCHRIST, M., WOTTON, I. D. P., DONALDSON, R., SISSON, R. B., MACFARLANE, R. G., JOPE, H. M., O'BRIEN, J. R. P., PETERSON, J. M. AND STRANGEWAYS, D. H. 1948.—Determination of Haemoglobin. Precision of Calorimetric Methods. *Lancet*, **2**, 563—566.

LONGHEED, M. W., SWEET, W. H., WHITE, J. C. AND BREWSTER, W. R. 1955.—The use of hypothermia in surgical treatment of vascular lesions. *J. of Neurosurgery*. **12**, 240—255.

MEYER, J. S., FANG, H. C. AND DENNY-BROWN, D. 1954.—Polarographic study of cerebral collateral circulation. *Archive, of Neurology and Psychiatry*. **72**, 296—312.

NESARAJAH, M. S., SENEVIRATNE, K. N. AND WATSON, R. S. 1961.—Electroencephalographic changes in Ceylonese Boxers, *Brit Med. Journ.* March 25 Vol. I, p. 866.

TABLE

Case No.	Age	Sex	Hb%	Hb. gm. 100c.c.	R.B.C./ cu.m.m.	P.C.V.	M.C. H.C.	Oximeter Readings%	Summary of E.E.G. Findings.
1.	35	M	25	3.7	3,480,000	23	16	81	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
2.	55	M	25	3.7	2,230,000	20	18.5	87	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
3.	39	M	25	3.7	2,640,000	19	19.5	—	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
4.	18	M	20	2.96	2,290,000	21	14.1	90	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
5.	65	M	25	3.4	1,350,000	19	17.9	85	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
6.	70	M	32	4.74	2,740,000	21	22.6	86	Diminished amplitude potentials 8-13/sec. of 5-20 microvolts amplitude.
7.	70	M	32	4.74	3,710,000	22	21.5	86	Diminished amplitude potentials 8-13/sec. of 5-20 microvolts amplitude.
8.	55	M	32	4.74	1,350,000	22	21.5	88	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
9.	69	M	32	4.74	2,350,000	18	26.3	83	Diminished amplitude potentials 8-13/sec. of 5-20 microvolts amplitude.
10.	65	M	40	5.92	2,610,000	23	25.7	82	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
11.	65	M	40	5.92	2,670,000	19	31.1	82	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
12.	45	M	20	2.96	1,700,000	12	24.7	83	Diminished amplitude potentials 8-13/sec. of 5-20 microvols amplitude.
13.	50	M	20	2.96	1,260,000	9	32.9	88	Diminished amplitude potentials 8-15 microvolts amplitude.
14.	39	M	20	2.96	2,140,000	9	32.9	84	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
15.	72	M	22	3.25	1,850,000	9	36.1	87	Diminished amplitude potentials 8-13/sec. of 5-20 microvolts amplitude.
16.	35	F	22	3.25	1,090,000	10	32.5	80	Diminished amplitude potentials 8-13/sec. of 5-20 microvolts amplitude.

17.	19	F	22	3.25	1,910,000	11	29.5	84	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
18.	32	F	21	3.10	2,210,000	16	19.5	86	Diminished amplitude potentials 8-13/sec. of 5-20 microvolts amplitude.
19.	29	F	20	2.96	830,000	10	29.6	85	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
20.	30	F	22	3.25	1,610,000	13	25	82	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
21.	26	F	40	5.92	2,210,000	22	26.9	88	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
22.	30	F	25	3.70	2,370,000	18	20.5	86	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
23.	23	F	35	5.18	2,030,000	18	28.8	80	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
24.	27	F	18	2.66	1,000,000	14	19	84	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
25.	66	M	30	4.44	2,060,000	16	27.8	84	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
26.	35	F	40	5.92	2,350,000	21	28.2	86	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
27.	60	M	20	2.92	2,230,000	12	24.7	84	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
28.	60	M	31	4.59	2,290,000	17	27	88	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
29.	55	M	35	5.18	3,040,000	19	27.2	88	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
30.	35	M	35	5.18	2,360,000	19	27.2	91	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
31.	35	M	25	3.7	1,480,000	14	26.4	89	Within the limits of normal variation 8-13/sec. of 30-50 microvolts amplitude.
32.	40	M	25	3.7	1,820,000	19	19.5	85	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
33.	50	M	20	2.96	2,350,000	16	18.5	90	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
34.	51	M	25	3.7	2,370,000	21	17.6	89	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.

35.	70	M	38	5.62	2,380,000	18	31.2	87	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
36.	45	M	30	4.44	2,760,000	15	29.6	81	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
37.	58	M	20	2.96	1,420,000	11	26.9	84	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.
38.	30	M	40	5.92	2,110,000	18	32.9	82	Diminished amplitude potentials 8-13/sec. of 5-15 microvolts amplitude.