14538

An Experimental Study of Monopolar and Bipolar Derivations in the Human Electroencephalogram.*

ROBERT COHN. (Introduced by C. E. Leese.)

From the Blackburn Laboratory, St. Elizabeth's Hospital, Washington, D.C.

A prominent feature of the normal human electroencephalogram, in transverse bipolar derivations, is the large amplitude of the alpha waves obtained from the occipital regions as compared to those from the frontal and parietal regions. Another outstanding characteristic of the human EEG is the generally higher amplitude of the wave-forms from the frontal and parietal leads in "monopolar," as compared to "bipolar" derivations from the same leads.[1] The latter property is most marked when the reference electrodes for the monopolar leads are placed on the ear lobes or in the mastoid regions. Experiments were devised to determine the basic factors responsible for these phenomena.

Method. Cadavers were used in all experiments. The post-mortem interval varied from 3 hours to 4 days. The variation in elapsed time from death to experiment had no important influence on the uniformity ot the results. A small trephine hole was made in the skull. The dura was then split and shielded copper wires, sealed in glass† were inserted through the skull opening into the brain substance to a depth of from 1 to 3 cm. The depth of insertion, between the ranges noted, was in no way critical. The source of artificial potential differences was obtained from a Hewlett Packard type 200D audio oscillator. The output voltage of the oscillator was regulated to give an approximately 2 mm amplitude deflection when recording from the transverse frontal leads. The oscillator voltage necessary to give the above deflection (with standard amplifier gain) was of the order of 50 milli-volts. The voltage was maintained at the proper determined value throughout the experiment. The resistance across the stimulus leads in contact with the brain substance was estimated to be 1 megohm. The voltage changes on the scalp surfaces were picked-up by small solder electrodes placed along symmetrical parasagittal lines over each cerebral hemisphere, generally in the frontal, parietal, and occipital regions. All monopolar leads were taken with either the ear lobes or the mastoid regions as reference points. Graphic recordings were made with an A.M. Grass 3 channel ink-writing oscillograph. Resistance measurements were made with an RCA Junior Voltohmist.

Results. Early in the investigation it became clear that with an artificial electric dipole in the occipital region a non-linear attenuation of *amplitude* resulted when the pick-up electrodes (bipolar) were linearly spaced 1,5,10,15 . . . cm from the region of stimulation. This phenomenon was most distinct when the pick-up electrodes were placed over the convex surface of the head. This non-linear attenuation is shown in the top 3 lines of Fig. B.

The marked similarity in amplitude characteristics between the normal human EEG in the transverse derivations (top 3 lines of Fig. A) and that of the artificially generated EEG from similar leads (top 3 lines of Fig. B) is obvious.

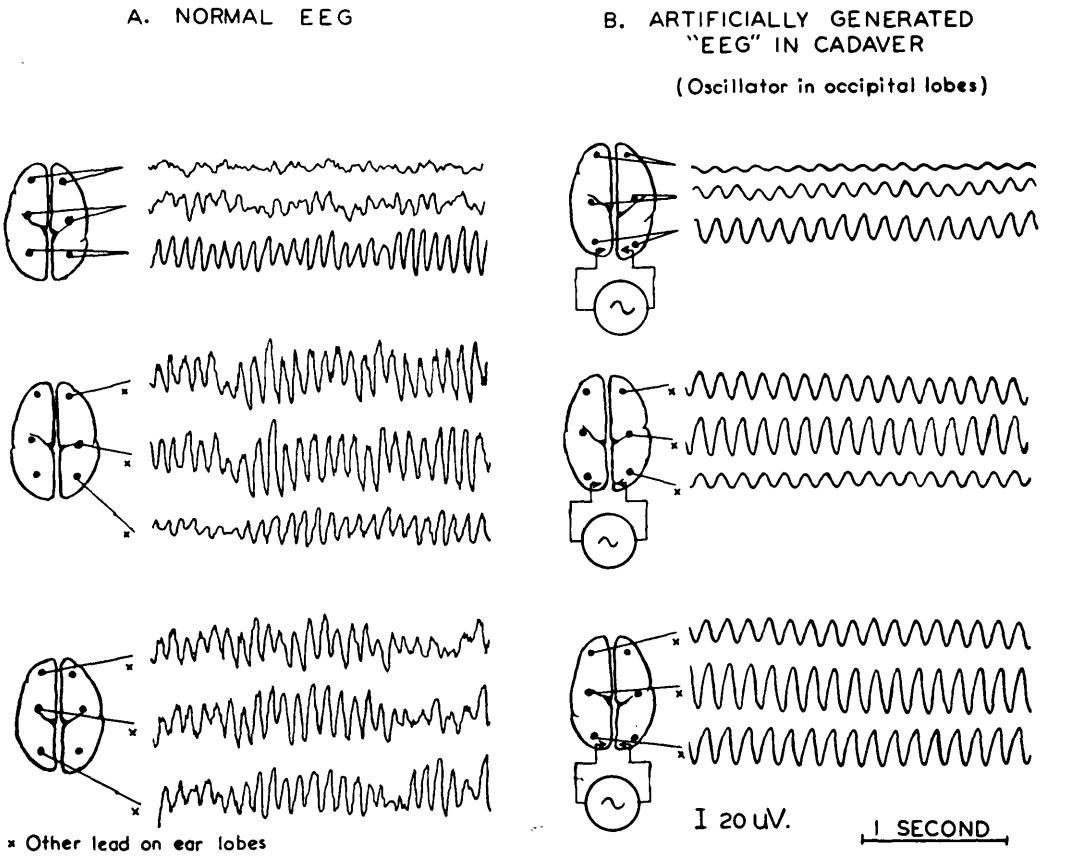
When the oscillating voltage was placed in the frontal region the findings were reversed, that is the amplitude was greatest in the frontal region. Hence, it is apparent that the amplitude of the waves picked-up by the bipolar technic is a non-linear function of the distance of derivation from the region of disturbance.

Monopolar derivations (with respect to the

* This work was aided by the Supreme Council, 33° Scottish Rite, Masons of the Northern Jurisdiction.

1 Rubin, M. A., *J. Neurophysiol.*, 1938, **1**, 313.

† The protruding edges of the sealed wires were cut flush and ground close to the edge of the glass in order to keep the area of direct stimulation as restricted as possible.



ear lobes) when using artificial electric dipoles, invariably show wave-forms of relatively large amplitude in all leads. This phenomenon is independent of the locus of the artificial source of potential difference (whether right, left, or middle in the frontal, parietal, or occipital regions). The lower 2 sets of simultaneous recordings of Fig. B are monopolar derivations with the stimulus dipole in the right occipital region. The similarity of these wave-forms to those seen in the normal human EEG (lower 6 lines of Fig. A) is remarkable. The minor variations of amplitude in the monopolar leads of the artificial system appear to be the result of local resistances.

Discussion. The marked similarity between the "spontaneous" and the artificial EEGs strongly suggests that the monopolar-bipolar amplitude differences observed in the normal human EEG are not primarily conditioned by the brain physiology; but are more probably conditioned by the attenuating properties of the anatomical components of the head and brain.

An electric dipole placed in the occipital regions is capable of giving sequences of waves that are similar, at least in amplitude characteristics, to those observed in the normal human EEG, using similar electrode placements. This fact lends strong support to the early hypothesis of Adrian[2] that the alpha rhythm of the EEG is primarily generated in the occipital lobes. Hence, even though it has been conclusively shown that other regions of the intact brain[3] as well as segments of brain tissue[4] under special conditions, will produce sequences of quasi-periodic potential oscilla-

2 Adrian, E. D., and Yamagiwa, D., *Brain*, 1935, **58**, 323.

3 Kornmuller, A. E., *Die Bioelektrischen Erscheinungen der Hirnrindfelder*, Leipzig, George Thieme, 1937.

4 Libet, B., and Gerard, R. W., *J. Neurophysiol.*, 1939, **2**, 153.

tions, the important fact appears to be that the main amplitude component of the usual clinical EEG can be duplicated by the spread of focal occipital potentials.

Conclusions. It has been shown that the important characteristic *amplitude properties* of the alpha component of the normal human EEG, in the usual monopolar and bipolar derivations primarily depend on the attenuating properties of the tissue through which the potential difference is transmitted. Moreover, noting the correspondence between waveforms seen in the normal EEG and those produced by an artificial occipital electric dipole in the cadaver, it is clear that the spread of an occipital electric disturbance is an excellent model for the production of the amplitude characteristics of the basic alpha component of the normal EEG.

14539 P

Serial Studies of Oxygen and Carbon Dioxide Content of Human Cord Blood.

WM. J. DIECKMANN AND SYLVIA KRAMER.

From the Department of Obstetrics and Gynecology, The University of Chicago and The Chicago Lying-In Hospital.

The reports of human cord blood studies are based on one sample obtained either after vaginal or abdominal delivery. Several investigators obtained blood at cesarean section but so far as we know no one has described a method which permits repeated sampling of fetal blood.

Haselhorst and Stromberger[1] delivered the umbilical cord in 8 cesarean sections, performed under spinal anesthesia on patients not in labor, and stated that the oxygen content of both arterial and venous blood was less than that found after vaginal delivery. They attributed the increased oxygen content to the uterine contractions forcing more maternal blood through the placenta. Their average figures are given in Table I.

Eastman's[2] average figures for blood obtained after vaginal delivery are also listed. He delivered the cord in one cesarean section, clamped off a segment from which arterial and venous bloods were obtained.

We find it feasible in most cesarean sections to deliver the umbilical cord through a small incision in the uterus and either inject drugs into the fetal circulation or withdraw repeated specimens of fetal blood. Since most of our cesarean sections are performed under local anesthesia, ideal conditions are available for obtaining serial specimens of fetal blood with the fetus still *in utero*. We have drawn 2 to 3 cc of blood from the umbilical vein and artery. No more than 30 cc of blood should be taken from term babies and much less from premature fetuses. The time interval in these experiments was 5 minutes, but in some unreported studies of placental permeability it was 15 minutes.

An interval of 30 minutes is probably the maximum because further prolongation of the operation increases the danger of maternal infection. Furthermore, in operations performed under local or continuous caudal anesthesia there is a mental strain due to the operation and the uncomfortable position on the operating table.

The fetal heart rate must be counted frequently either by use of a sterile stethoscope or by palpation of the umbilical arteries. If the rate decreases below 100 per minute the baby's head is delivered, 0.3 cc solution posterior pituitary are injected into the uterine wall and after one minute the fetus is slowly delivered. After the uterus has contracted the cord is

[1] Haselhorst, G., and Stromberger, K., *Z. f. Geburt. u. Gynäk.*, 1932, **102**, 16.

[2] Eastman, N., *Bull. Johns Hopkins Hosp.*, 1930, **4**, 221.