SPECIAL ARTICLE*

THE CLINICAL USE OF ELECTROENCEPHALOGRAPHY

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Although there had been earlier suggestions that cerebral activity is associated with electrical alterations, the first reliable demonstration that alterations in electrical potential can be recorded from the brain was published by Hans Berger1 in 1929. With his many publications in the early 1930's interest began to be shown in this phenomenon. In 1935 Gibbs6 published (in collaboration with Davis and Lennox) his first paper on the electroencephalogram in epilepsy, and the next year Jasper9 followed. In 1935 Foerster and Altenburger4 noted the changes in the electroencephalogram associated with intracranial tumors. In 1936 Walter,13 and in 1938 Case and Bucy3 confirmed these observations. Since then the interest in electroencephalography has steadily increased. Unfortunately there has been, at times, an overly enthusiastic clinical utilization of electroencephalography, and claims have been made as to its diagnostic values that are not in accord with scientific observations. It is important, therefore, that we make a dispassionate analysis of electroencephalography. What it is; what uses can be made of it; and, how it can be of assistance in clinical medicine, particularly in clinical neurology and neurological surgery.

By applying a number of electrodes to various parts of the human head, connecting them with suitable amplifiers and recording equipment, it is possible to record alterations in electrical potential between two different points. Commonly these electrodes are applied to the scalp overlying the cerebrum (although at times electrodes may be placed over the cerebellum, in the nasopharynx, on the ears or on the nose). The electrodes are usually flat, round metal discs about 1 cm. in diameter which are attached to the shaved scalp with a suitable adhesive. (Occasionally needle electrodes which can be inserted into the scalp have been used but in general these have been unsatisfactory.) By means of these electrodes variations in electrical potential between any two points can be recorded. Sometimes both points overlie one cerebral hemisphere; sometimes one is on one side and one on the other, and on other occasions comparisons may be made between a point over the cerebrum and a point on an ear or the nose, which the electroencephalographer hopes is "inactive" or "indifferent." It has been shown that the alterations in electrical potential thus recorded may result from changes in electrical potential within the cerebrum, particularly in the cerebral cortex. In fact it is in the hope of studying such changes within the cerebrum that

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the electroencephalogram is made. It is important, however, that the
electroencephalographer be thoroughly familiar with all of the other sources
that may produce changes in electrical potential between any two of his
electrodes, and that may prove misleading in his interpretation. Among
the more obvious of these are the action of the heart, showing an electrocardio-
gram in the record; muscular activity of the fronto-occipitalis muscle or the
muscles of the eyes or of mastication; or movement of an electrode in rela-
tion to the scalp; or such extraneous factors as electrical defects in the equip-
ment, or the standard 60 cycle electrical current, or the electrical activity of
unrelated electrical equipment in or near the hospital or laboratory. It is
also important that the electroencephalographer recognize that the electro-
encephalographic equipment which is now quite standardized is providing
him with an incomplete picture of the alterations in electrical potential
occurring within the brain. This is true for two principal reasons—the equip-
ment itself and the nature of the examination. The equipment has certain
limitations built in it which restrict the frequency of alterations in potential
that it is able to record. It is obvious that an ink-writing instrument writing
on paper moving at the rate of 3 cm. per second (which is standard) cannot
record the high frequencies which are present and which can be recorded,
for instance, by a cathode ray oscillograph. The fact that no one knows the
significance of these higher frequencies which the present equipment com-
pletely ignores is no evidence that these frequencies are less significant than
those with which we are more familiar. But more important still is the na-
ture of the entire examination. Alterations in electrical potential in the
scalp are being recorded which it is hoped and believed are a reflection of
the electrical activity within the cerebrum. At the very outset it must be
obvious that recording from 16, 32 or 100 electrodes on the scalp can give
but a very rough idea of the electrical activity within the millions of neurons
and neuronal connections within the brain itself. In attempting to record the
activity of the millions of units within the brain with a mere handful of
recording electrodes we must be recording a summation of a large number
of intracerebral units. If the intracerebral units were firing completely in-
discriminately the alterations in electrical potential of half of them would
cancel out the alterations in the other half and the electroencephalogram
would be a perfectly flat line, i.e. we would record nothing. But, this com-
plete silence of the electroencephalogram would not mean complete inac-
tivity in the brain. In fact it might be consonant with intense activity. The
fact that in the electroencephalogram we record something is evidence that
at different times variable numbers of intracerebral units function syn-
chronously, producing a sufficient preponderance of alteration of electrical
potential in one direction to be recorded. In fact nervous activity within the
brain is commonly associated with asynchronous neuronal activity, while
inactivity permits a large number of neurons to assume a synchronous basic
or inherent rhythm. Thus when the subject is lying relaxed with his eyes
closed the basic alpha rhythm of 8 to 10 waves per second becomes promi-