PATHOLOGICAL PHYSIOLOGY AND GENERAL PATHOLOGY

REACTION OF THE CEREBRAL CORTEX AND OF THE HEART DURING OPERATIONS ON THE HYPOPHYSIS AND THE HYPOTHALAMIC AREA

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Physiologic investigations in the neurosurgical operating theater permit valuable studies of physiologic and pathologic features of the central nervous system on man, viz. functional connections between the cerebral cortex and subcortical formations, central regulation of the cardio-vascular system etc.

In order to study the functional cortical-subcortical connections electroencephalographic records were taken during operative removal of tumors (of the hypophysis, third ventricle and sella turcica) which is accompanied by stimulation of hypothalamic nuclei.

Some scattered references to studies on the influence of the hypothalamus on cortical potentials are available in the literature. Thus, stimulation of the hypothalamus "en masse" was noted to be associated with changes in cortical potentials in man [3].

In another communication [4] it was shown that during and after stimulation of the hypothalamus long-lasting changes in the spontaneous electroencephalogram could be observed; these could be interpreted as reflection of excitation since the EEG discharges on both hemispheres showed enhancement of both frequency and amplitude.

Lesions of the medulla do not alter substantially the electric activity of the cortex while lesions of the midbrain and diencephalon evoke gross bilateral changes in the EEG [2]. The author cited concludes from this that electrogenesis and, consequently, the functional state of the cortex depend both on the specific and non-specific projection systems. According to his data stimulation of the brain stem produces diffuse desynchronization of cortical potentials while destruction of the rostral parts of the brain stem leads to synchronization of slow waves and bursts of spindles.

The present investigation is concerned with the study of cortical reaction to hypothalamic stimulation in the course of surgical intervention for removal of tumors in this area.

EXPERIMENTAL METHODS

Those brain stem lesions were chosen for investigation in which the tumor focus requiring surgical intervention was found in the region of the sella, hypothalamus or optic chiasma. It is important that there is no primary involvement of the cortex in tumors of this localization. Since the very close connection between the hypothalamic area and cardio-vascular function is known from numerous experimental and clinical observations [1] simultaneous recording of the electrocardiogram was carried out together with the electroencephalogram. The material for the present work consisted of cases of pituitary adenoma (16 patients), third ventricle tumors (2 patients) and tumors in the sella turcica area (4 patients).

Reaction of the cortex at various stages of the operative procedure was studied by means of continuous recording of the bioelectric potentials from the posterior parietal and parietal areas of both hemispheres, i.e., cortical areas distant from the zone of neurosurgical intervention which used the frontal approach to the area of the sella and hypophysis with trephining in the frontal area and lifting of the base of the frontal lobe; scalp recordings were used.

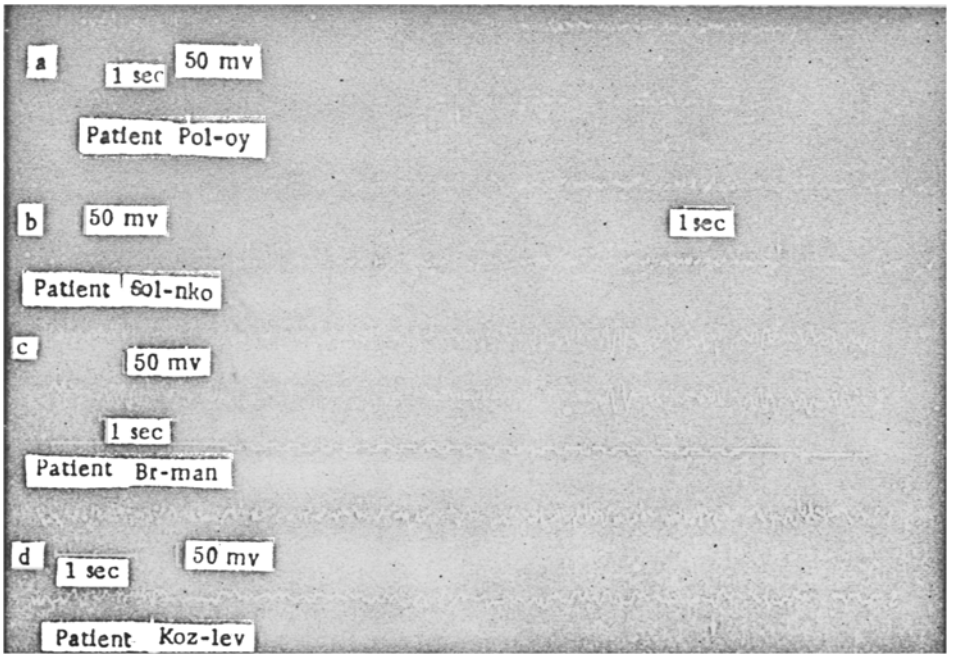

Fig. 1. Main types of electroencephalograms (a, b, c, d) recorded before operation in patients with pituitary tumors, at rest and with extraneous stimuli.
1) Right parieto-occipital area; 2) left parieto-occipital area.

The cortical potentials were led off by means of electrodes 8 mm in diameter and about 1 mm thick, made of pure tin. The electrodes were covered by a thin layer of a special paste ensuring minimal resistance between the electrode and the scalp. Bipolar leads proved to be the most reliable and convenient under operating theater conditions. The paste-covered electrodes were fastened to the scalp by strips of adhesive tape; they were placed over the occipital and parietal areas of both hemispheres.

In order to record the electroencephalogram and the electrocardiogram on the same strip a special combined electroencephalograph was used which was provided with automatic compensation of alternating current induction and required no screening of the theater. With the use of filters frequencies from 1 to 100 cycles per second could be recorded.

EXPERIMENTAL RESULTS

The main types of electroencephalograms observed prior to operation in patients with pituitary tumors both at rest and upon external stimulation are presented in Fig. 1. In 6 of 16 patients the original biopotential picture is dominated by a well formed, synchronous alpha rhythm of normal frequency and amplitude with marked reaction (diminution) to light stimuli (Fig. 1, a). In three patients the alpha rhythm was unstable with fairly frequent periods during which it was depressed. In these cases stimulation (such as prolonged clenching of fists) evokes, after a definite latent period, increased synchronization of the alpha rhythm, the latter disappearing upon cessation of stimulation (Fig. 1, b). In four patients fairly high voltage hypersynchronized

rhythm was seen over all areas of both hemispheres; this rhythm resembled the alpha rhythm in its appearance but differed from it in its properties since it was unchanged upon light and other, even rhythmic, stimulation, and did not usually exceed 7 to 8 cycles per second in frequency (Fig. 1, c).

This type of EEG is encountered more frequently upon extension of the tumor beyond the limits of the sella into supra- and parasellar areas. And, finally, when large pituitary tumors extending from the sella to the floor of the middle fossa or into the third ventricle are present considerable changes in the EEG consisting of complete or sustained absence of alpha rhythm and predominance of diffuse delta waves alternating, at times, with fast activity (Fig. 1, d) are seen.

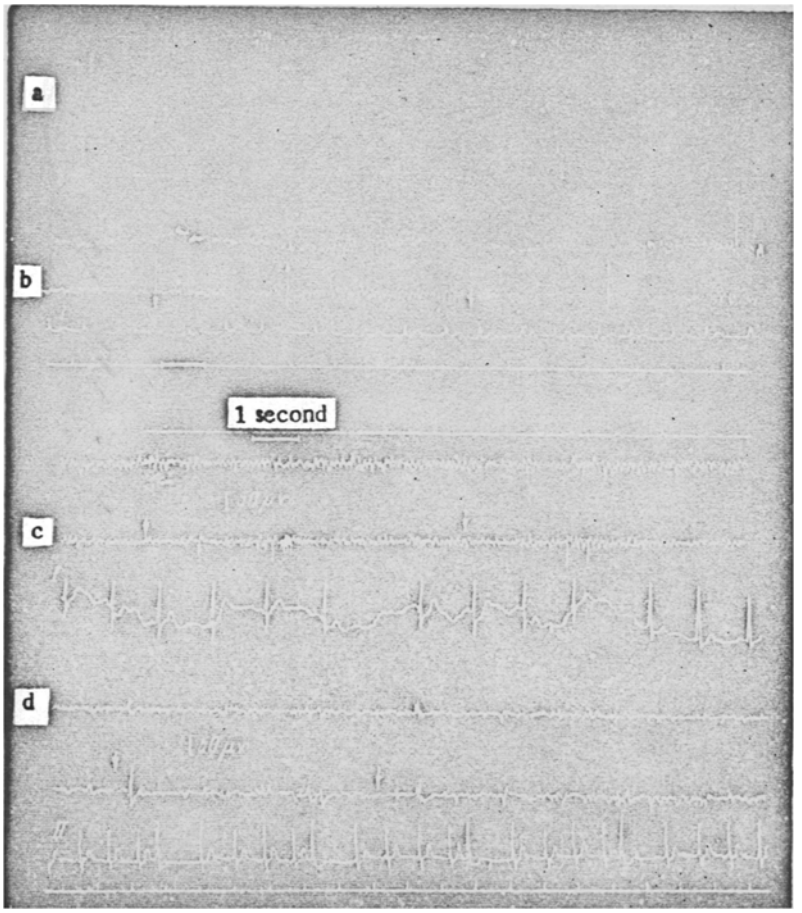

Fig. 2. Electroencephalogram changes in the posterior parietal areas and changes in the electrocardiogram upon stimulation of the hypothalamic region during removal of pituitary tumor.
a) Before trephining – normal depression of alpha rhythm on switching on a light; b) at the moment of stimulating the hypothalamic region with a tampon depression of alpha rhythm with subsequent slowing of the rhythm of cardiac contractions are noted; c) in another patient stimulation of the hypothalamic region is associated with bursts of fast activity on the contralateral hemisphere followed by definite slowing of cardiac contractions; d) the same in patient Sh-k suffering from encephalitis; upon the surgeon's approach to the basal ganglia the EEG shows bilateral bursts of fast activity with subsequent slowing of cardiac contractions.
Records from above down: electroencephalogram from the right occipito-parietal area, electroencephalogram from the left occipito-parietal area, lead I, time marker (1 second), also stimulus marker.

Results of simultaneous investigation of cortical and cardiac reactions during operative intervention in the hypothalamic region are presented in Figs. 2 and 3. In the case of patient N-v with a small pituitary adenoma a normal alpha rhythm, reactive to light, was recorded during the first stages of the surgical procedure. The electrocardiogram was also within normal limits (Fig. 2, a).

The next record (Fig. 2, b) shows a reaction consisting of alpha rhythm desynchronization and appearance of faster frequencies at the moment of stimulation of the hypothalamic region during removal of the pituitary tumor. Two seconds later a reaction is seen in the electrocardiogram when the rhythm of cardiac contractions is slowed appreciably (Fig. 2, b). The desynchronization reaction, i.e., cortical excitation, and slowing of cardiac contractions are in this particular case of short duration disappearing rapidly on cessation of hypothalamic stimulation.

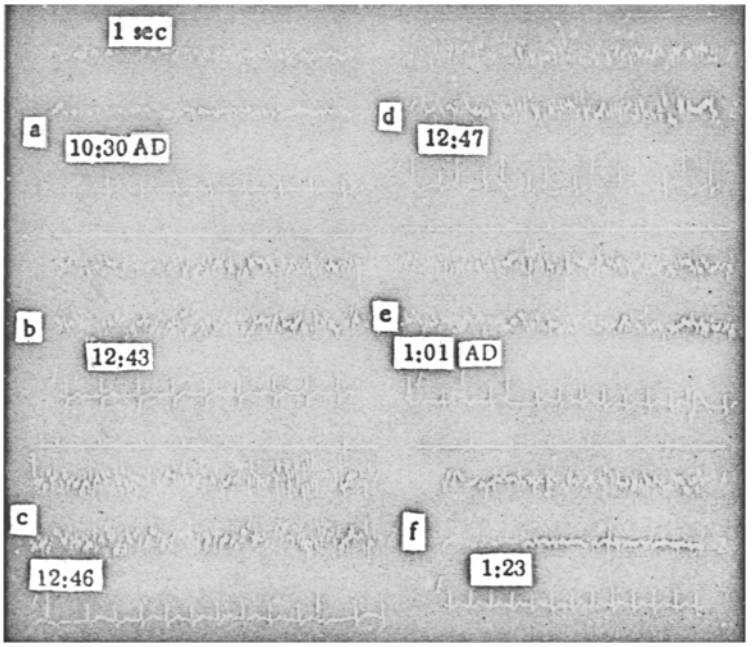

Fig. 3. Changes in the electroencephalogram and electrocardiogram at various stages of operative removal of pituitary adenoma under barbiturate anesthesia in patient M-na.
a) Before anesthesia; b) 4 minutes after administration of thiopental Na – increasing amplitude of fast activity; c) at the moment of removal of adenoma by suction, extrasystoles appearing after every 9 normal cardiac complexes; d) placing of tampon in the sellar region associated with sustained alternation of sinus and atrioventricular rhythms; e, f) gradual return to normal of the electrocardiogram toward the end of operation.
Records from above down: time marker (1 second); right occipito-parietal area; left occipito-parietal area, electrocardiogram, Lead I.

The next example illustrates even more clearly the appearance of cortical impulses and subsequent slowing of cardiac contractions at the moment of removal of the pituitary tumor (Fig. 2, c). In this case the corticopetal impulses evoke not desynchronization of the alpha rhythm as was the case in the preceding patient, but the appearance of bursts of higher voltage impulses on the contralateral hemisphere following which slowing of cardiac contractions becomes clearly visible in the electrocardiogram.

When more pronounced changes in the original electroencephalogram are present in the case of large tumors extending into the middle fossa stimulation of the hypothalamic region during removal of the tumor is seen to be accompanied by a more prolonged reaction of cortical excitation in the form of frequent sharp waves. This reaction was coincident with a change from normal frequency of cardiac contractions (80 per minute) to prolonged slowing – down to 48 per minute. In these cases, in addition to slowing of cardiac contractions, it was noted that extra auricular contractions were occurring. Such cortical reactions followed by slowing of cardiac activity were observed not only during intervention in the sellar area but also upon temporal lobe approach to the basal ganglia (Fig. 2, e).

In the example cited, stimulation of the basal ganglia was carried out against the background of ether anesthesia (to prevent hyperkinesis). Bursts of cortical discharges appear in response to stimulation of the hypothalamic region against the background of lowered amplitude of spontaneous cortical activity (as the result of ether anesthesia). Attention is drawn to the fact that the cortical reaction occurs prior to sinus bradycardia; this may indicate transmission of excitation from the cortex to the vagal center.

The neurosurgeons removed some pituitary tumors under barbiturate anesthesia which is usually used after examination of the optic chiasma and the sella (Fig. 3). Stimulation of the hypothalamic region under barbiturate anesthesia is not clearly reflected, electrographically, in the cortex since during the first stage of anesthesia, particularly after administration of thiopental sodium, sustained stimulation is observed; this is expressed electroencephalographically by high voltage fast activity (16-22 cycles per second) recorded continuously over a period of twenty or more minutes. Similar EEG pictures were seen under the influence of barbiturate in patients in whom no pathologic focus was discovered.

Considerable changes in cardiac reactions are seen against the background of general anesthesia. Thus, upon introduction of a tampon into the sellar region after removal of the tumor sustained heterotopy was observed. Analysis of the dynamics of the electrocardiogram (Fig. 3) revealed that foci of excitation arise at the same time in the atrioventricular node and the bundle of His together with excitation emanating from the sinus node.

It may be supposed that these manifestations of heterotopy under conditions of general anesthesia are caused by direct influence of subcortical impulses on the functional properties of nervous apparatus and conducting system of the heart. The rapid reversal of these changes in cardiac activity (Fig. 3, e, f) indicates, from our point of view, adequate functioning of the cardiac muscle itself and of coronary circulation.

The comparison of electroencephalographic and electrocardiographic data obtained simultaneously during operative removal of pituitary tumors thus permits the study of cortical and cardiac reactions to hypothalamic stimulation in man. Cortical reactions to stimulation of the hypothalamic zone are expressed electrographically by desynchronization of the rhythmic potentials lasting for 3-5 seconds and longer. During lowering of alpha rhythm amplitude upon hypothalamic stimulation bursts of sharply outlined waves are observed. One to two seconds after the reaction of cortical excitation changes in the direction of sinus bradycardia appear in the electrocardiogram lasting from two to three seconds to several minutes.

Such cortical reactions associated with subsequent slowing of cardiac activity were also observed during manipulation in the region of the basal ganglia. When the hypothalamic region is stimulated against the background of barbiturate anesthesia the cortical reaction is often not reflected clearly in the electroencephalogram owing to predominance of sustained stimulation in the cortex under the influence of the first stage of barbiturate anesthesia. At the same time stimulation of the hypothalamus under these conditions is reflected in the electrocardiogram by a picture of heterotopy; in addition to excitation proceeding from the sinus node, foci of excitation arise in the atrioventricular node and the bundle of His.

SUMMARY

Data concerning the study of electroencephalograms (EEG) and electrocardiograms (ECG) are presented in this paper. These EEG and ECG were taken simultaneously during surgical removal of the tumors of hypophysis.

Investigations which were carried out on 22 patients show that reactions of the cortex to stimulation of the hypothalamic area may be demonstrated electrocardiographically by desynchronization of the rhythm of potentials or in appearance of "acute" potentials. These changes of ECG are especially pronounced if there is a decreased amplitude of the alpha rhythm in the initial EEG.

Similar manifestations of the cortical reactions, associated with the following sinus bradycardia, were revealed in manipulations in the area of the basal ganglia.

Transitional heterotopia was observed in the ECG of 5 patients in stimulation of the hypothalamus on the background of barbiturate narcosis.

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