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A RELIABLE METHOD FOR FREQUENCY AND AMPLITUDE ANALYSES IN ROUTINE ELECTROENCEPHALOGRAPHY IN MAN

C. BĂLĂCEANU, G. APOSTOL

The National Institute of Gerontology and Geriatrics, Bucharest, Romania

Summary. EEG changes during human normal ageing may be studied using rugged electrodes which have a great reliability. The EEG tracings are statistically processed taking two significant EEG parameters: frequency and amplitude, and using the planimetric method which is precise, simple and economical. The data obtained are analysed in a tridimensional Cartesian reference space which allows a graphic presentation of the EEG ageing process. A "k" index of normality is used to detect possible pathologic processes overlapped on the ageing ones.

Cross-section and especially longitudinal studies of the neuraxial ageing process necessarily imply the study of cortical electrogenesis. Interpretation of the EEG tracings is, however, extremely difficult as long as there are cases that can not be framed into a clear pathology.

EEG analysis of the ageing process implies in the first place a comparative study of the tracings obtained in vigil rest state. The parameters that have to be taken into account are the frequency and amplitude of the alpha rhythm. Yet, the ageing process imposes variations of these parameters within somewhat restricted limits. In order to show these variations it is necessary to use certain recording techniques of great reliability and methods for processing the standardized data so as to allow comparable results, especially in longitudinal studies (on the same individual).

Electrodes. In order to reduce the artefacts that may influence considerably the EEG tracings it is necessary a close appliance of electrodes to the surface of the scalp skin. The best suited for this purpose seem to be the rugged electrodes (Fig. 1), that can be applied using either bentonite or collodium paste (Fig. 2).

The rugged electrodes are placed on the skin using the 10–20 international system (Jasper 1958) so that the resistance of each electrode should not exceed 10 kΩ. The electrodes in our study were connected to a Mingograf EEG Junior Siemens-Elema as indicated in Figs. 3 a and 3 b. As results from Fig. 3 a, the analysis of the alpha rhythm is made using the C_3-P_3, P_3-O_1 and C_4-P_4, P_4-O_2 leads, and integration of these leads may be compared to the C_3-O_1 and C_4-O_2 leads shown in Fig. 3 b.

Statistical processing. In our studies the EEG tracings were obtained using a 0.3 time constant, a filtration 15 and a base recorder gain of the 50 microV, V = 10 mm, 30 mm/s paper rolling speed.

a. The tracings thus obtained were statistically processed through the planimetric method (Racotta, 1968) [1] for evaluation of the mean frequency and ampli-

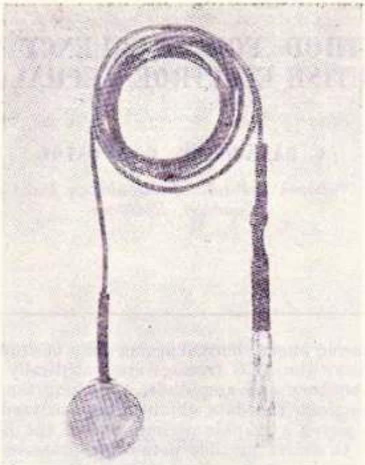

Fig. 1. — The rugged electrode.

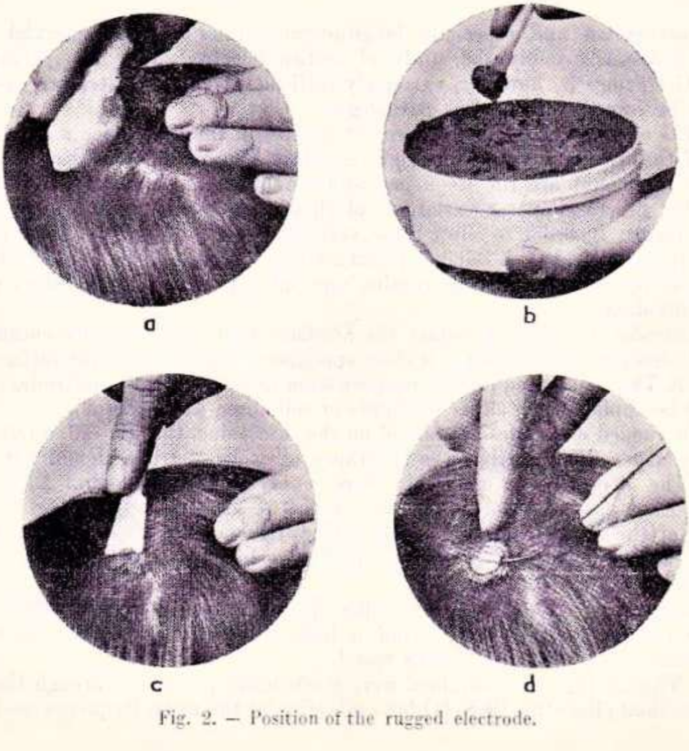

Fig. 2. — Position of the rugged electrode.

tude. This method seemed most suitable as it has an acceptable degree of accuracy and is less expensive. The procedure is to select a tracing segment (the one used in the analysis) 150 mm long which is the result of a 5 sec run (limited in Fig. 4

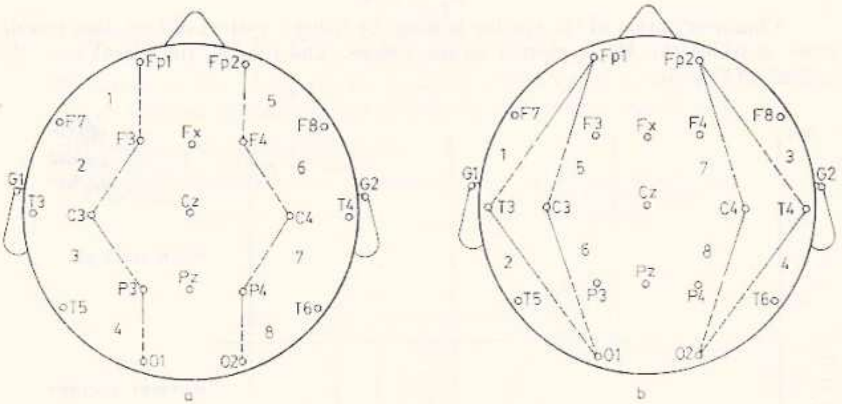

Fig. 3. — Scheme for placing the electrodes on the scalp skin.

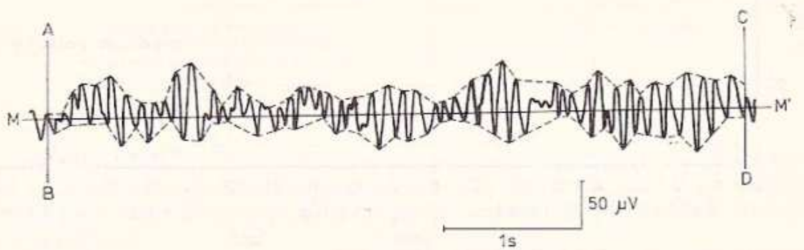

Fig. 4. — An example for computing the mean amplitude of the EEG tracings. The AB and CD segments encompass a 5-sec area. MM' = medial line; the dotted line joining the EEG waves represents the perimeter of the surface (the lined space) which is to be planimetered.

between AB and CD). This segment is divided into a superior and an inferior component by a horizontal line (MM' in Fig. 4) as near to the isoelectric line as possible. The surface covered by the EEG waves is measured in mm² using a planimeter and delineated by a contour joining the peaks of the waves (the lined surface in Fig. 4). The S value (in mm²) of the surface thus obtained is divided by the length in seconds of the analyzed segment [5] multiplied by rolling speed in mm/s of the paper. This yields the mean amplitude in mm (M_A mm) of the tracing under consideration according to the formula:

$$\frac{S}{5 \times 30} = M_A \text{ mm}$$

In order to obtain the mean amplitude in microV (M_A microV) it is considered 10 mm equals 50 microV. This yields an equivalency relation:

$$M_A \text{ microV} = M_A \text{ mm} \cdot 5$$

In order to obtain the mean frequency M_F the waves are counted either above or below the medial MM' line. The number "N" of waves obtained is divided by the length (in seconds) of the segment according to the formula:

$$M_F = N/5$$

Characterization of the tracing is made by using a system of Cartesian coordinates in which the M_F is plotted on the abscissa and the M_A (in microV) on the ordinate (Fig. 5).

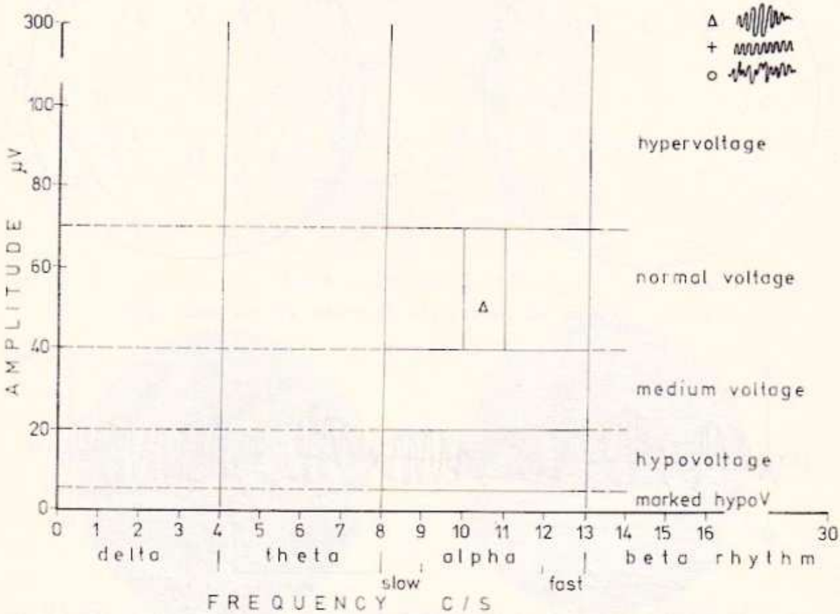

Fig. 5. — Table showing M_A, M_F and alpha rhythm morphism in an ideal case.

In a longitudinal study, characterization of the tracing for each subject may be done using a tridimensional Cartesian system which contains in addition, the time dimension indicating the successive moments (½ yr., 1 yr., 5 yrs., etc) selected for comparative analyses of the recordings.

In this way, one may obtain curves that express in the abstract space of the coordinates the cerebral ageing process as it is reflected at the EEG level.

It is worth mentioning at this point that the healthy adult shows an alpha rhythm frequency limited between 10—10.5 c/s and a mean amplitude (in the parieto-occipital leads) around 50 microV as results from the available statistical studies.

Beginning with the age of 60 a graded decrease in frequency down to 8—8.5 c/s for the 80—90 age decade accompanied by a slight decrease in amplitude (30—40 microV) has been noticed.

Besides frequency and amplitude other elements of the EEG tracings, such as morphologic characteristics, the dynamics of the response to hyperpnea, and to intermittent light stimulation, etc. may also be analyzed. This more complex analysis shows that with advancing age there is an increased latency.

b. For statistical processing of the EEG data we have also used an index of normality (k) defined by the relation:

$$k = \frac{M_F^2}{M_A \text{ microV}}$$

The value of this index (k) for healthy adults varies between 1.43—3.00. As Fig. 6 shows, any alterations of k are of pathological significance.

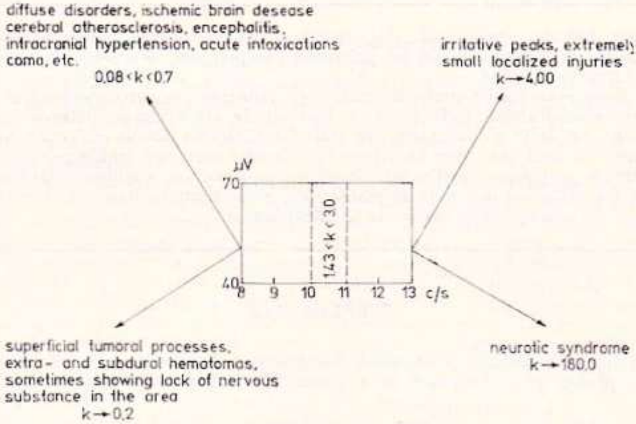

Fig. 6. — Value of the k index.

In space-replacing lesions (tumors, hematomas) involving the cortical areas the k index varies around 0.2. This expresses the fact that at the level of the damage the frequency (the delta rhythm) and sometimes amplitude of the EEG tracings are also reduced.

In diffuse cortical disorders (toxic, inflammatory, hypoxic, especially in cerebral atherosclerosis) the k index decreases to values ranging within 0.08—0.7.

In irritative cortical processes on the contrary, the k index may reach values as high as 4.00 (due to a considerable increase of the frequency, the amplitude of the waves reaches a hypervoltage value of 150—300 microV).

In neurosis, due to the flattening of the EEG tracings (decrease in amplitude) and the increase in frequency, the k index rises considerably (reaching a value of 180).

In the ageing process the k index does not change significantly, which means that the process takes place within normal limits. When these limits are exceeded, the k values are able to point out a pathologic factor superimposed on the normal ageing.

CONCLUSIONS

1. Longitudinal studies of the EEG changes during normal ageing may be successfully accomplished by using the rugged electrodes which offer a greater reliability.

2. The EEG tracings are statistically processed taking into account the two main EEG parameters, i. e. frequency and amplitude.

3. The planimetric method is used both for its greater degree of accuracy and its simplicity and inexpensiveness.

4. The data obtained are analysed in a tridimensional Cartesian reference space which allows graphic representation of the ageing process by EEG recordings.

5. Use of an additional factor, the k normality index allows to pinpoint pathologic processes associated to normal ageing.

Résumé. Pour l'étude longitudinale des modifications électroencéphalographiques au cours du vieillissement orthogère humain on préconise l'emploi des électrodes du type « rugged », qui ont une grande fiabilité.

Les tracés sont statistiquement traités, en étudiant les deux paramètres significatifs de l'électroencéphalogramme: la fréquence et l'amplitude. On utilise la méthode planimétrique, aussi bien pour son degré d'exactitude, que pour son caractère simple et économique. Les données obtenues sont analysées dans un espace de référence cartésien tridimensionnel permettant la représentation graphique du développement du processus de vieillissement électroencéphalographique. On utilise un indice de normalité « k », permettant la détection de certains processus pathologiques superposés au processus de vieillissement.

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