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STATE OF NARCOSIS INDICATION (FROM EEG DATA):  
A NEW STEP TOWARDS THE REALIZATION OF A  
BIOCONTROL ANAESTHETIC APPARATUS

L.A. Vodolazskij and N.Eh. Rabinovich

Nav. Med. Priborostr. 1 (1967) 58-62  
(from Russian)

DRIC Transl. No. 2806

May 1972

Translated by Lt.Cdr. P.N. Hiles



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Report delivered at the fourth International Congress  
on Medical Cybernetics which took place at Nice, France in 1966

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One of the most promising avenues of medical cybernetics is the development of biocontrol instruments. Instruments with biocontrol are finding ever wider applications in medical practice.

An essential task of modern medical technology is the construction of an anaesthetic apparatus with automatic delivery of the anaesthetic agent. This apparatus must ensure that the patient is placed under a given degree of narcosis and maintained in that state throughout the course of the operation.

To solve this problem, it was essential first of all to make an appliance which would enable the anaesthetist reliably to determine the state of narcosis of the patient and also the necessary dose rate for the anaesthetic.

One objective indicator giving reliable information on states of narcosis of a patient during an operation is the electrical activity of the brain.

In 1891, the Russian scientist V.Ya. Danilevskij noticed the effect of anaesthetics on the electrical activity of nervous tissue and discovered that, during deep narcosis, this activity is depressed<sup>(1)</sup>.

In 1937, Gibbs, studying the effect of ether narcosis on the electrical activity of the brain of animals, discovered its characteristic changes and proposed to use an EEG to control the depth of narcosis. However, until such time (at the end of the 40's) as it was possible to record a patient's EEG in the theatre, it was impossible for this method to be applied.

At the beginning of the 50's a number of authors<sup>(4,11,12,14)</sup> discovered a correlation between the clinical pattern of the effect of the anaesthetics on the organism of a patient undergoing an operation and his EEG. Accordingly electroencephalographic states of narcosis were worked out<sup>(5-9,11-13)</sup>. It was also established that the effects of various forms of anaesthetic on the EEG were more or less the same. Changes in the EEG reflect changes in the state of narcosis much sooner than the symptoms characteristic of such states.

However, changes in EEG during the effects of anaesthetizing agents are not specific; similar changes in the electrical activity of the brain of a patient can be caused by hypoxia and hypercapnia.

The first attempts to construct a device for automatically administering an anaesthetic in relation to the electrical activity of a patient's brain were made in the USA in 1950, but produced no positive results<sup>(15)</sup>.

The use of an EEG to determine the depth of narcosis during an operation is difficult, since wide experience of anaesthesiology is necessary in interpreting the EEG. Research teams therefore concentrated their attention on the construction of instruments to indicate the state of narcosis. The Japanese scientists Yamaguti and Murai in 1959 proposed an instrument with two dials on the face: one to register the lower frequencies (from 5 Hz downwards) in the EEG spectrum, the other to register the mean values of biopotential amplitudes. However, this instrument was not proceeded with, since it indicated only one, deep, stage of narcosis.

In our opinion, instruments of this sort should, in the simplest form, indicate the state of narcosis and also ensure the observation of changes in that state.

In 1961, work was started on the construction of an instrument which would satisfy these requirements in VNIIMP in conjunction with the Institute of Clinical and Experimental Surgery. The instrument was called the State-of-Narcosis Indicator ISN-1 (Fig. 1). The first stage of the work consisted in determining the predominant frequencies in a patient's EEG at certain stages of ether narcosis and defining the borderline frequencies between the stages.

In the theatre, the EEG of a patient who is in a certain state of narcosis, is inscribed on magnetic tape. After this, in the laboratory, the signal from the tape recorder after demodulation is fed into an

analyzer having 10 interchangeable filters with discrete frequencies from 0.5 to 30 Hz and an integrator.

By means of a filter tuned to a frequency of 0.5 Hz, the inscription is read off on the magnetic tape. The overall electrical activity of the brain having a frequency close to 0.5 Hz is fixed by the integrator. Then the filter is exchanged for another one tuned to a frequency of 1 Hz and the cycle is repeated.

An example of the results of work with this analyzer using various filters is shown at Fig. 2.

Having analyzed a large number of spectrograms (about a hundred), one can determine the borders of electroencephalographic stages of ether narcosis. The stage of frequent waves (theta waves) lies in the frequency band 12-29 Hz, (pre-dominant frequencies in this stage : 15 and 20 Hz); the stage of compound waves (beta waves) = 5-17 Hz (pre-dominant frequencies: 6 and 9 Hz) and the stage of rare waves (delta waves) = 1-5 Hz (pre-dominant frequencies: 1, 1.5, 2 and 3 Hz).

The stages of frequent and compound waves in the frequency range 12-17 Hz overlap. This is because it is difficult to lay down a sharp division between these stages on the basis of the patient's clinical symptoms.

We chose a conventional borderline frequency between frequent and compound waves of 14 Hz. The correctness of this choice was confirmed by clinical conditions.

In the ISN-1 an amplitude barrier was used to simplify the recording of data on the depth of narcosis.

To indicate the state of narcosis on the ISN-1 we used a pointer type DC measuring instrument and a device transforming the oscillations of constant amplitude but of variable frequency into direct current. The greater the amplitude, the higher the frequency.

The scale of the instrument had three different coloured sectors, corresponding to the three electroencephalographic stages of ether narcosis. The distribution of the scale sectors of the pointer-type indicator were corrected during clinical experiments which were carried out in the Institute of Experimental and Clinical Surgery and in the Surgery Department of the Central Institute of Further Education for Doctors. The indications of the ISN-1 instrument coincided with information on the state of narcosis according to clinical charts and the patient's EEG.

Results of clinical tests showed a very accurate correlation between the indications of the ISN-1 instrument, clinical charts and the EEG

Use of the ISN-1 in medical establishments enables a store of experience and statistical material and determination of the limits of the instrument's application to be built up.

At the autumn Leipzig fair in 1965 the ISN-1 State-of-narcosis Indicator received a gold medal.

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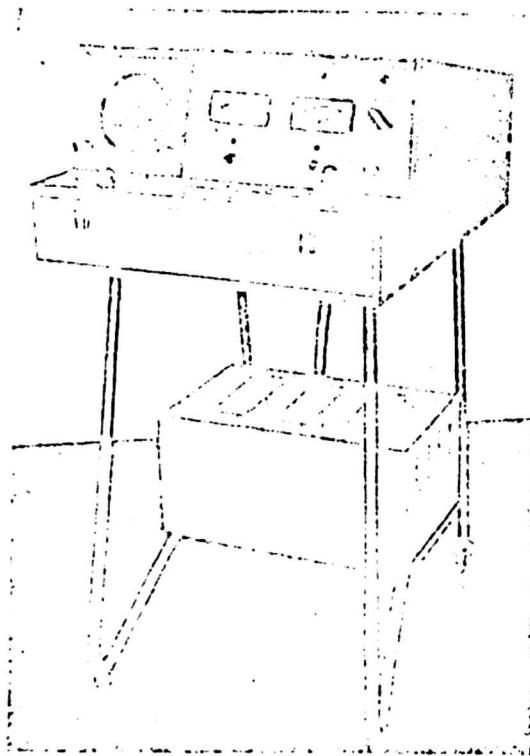


Fig. 1. General view of the ISN-1

1. State of frequent (theta) waves
2. State of compound (beta) waves
3. State of rare (delta) waves.

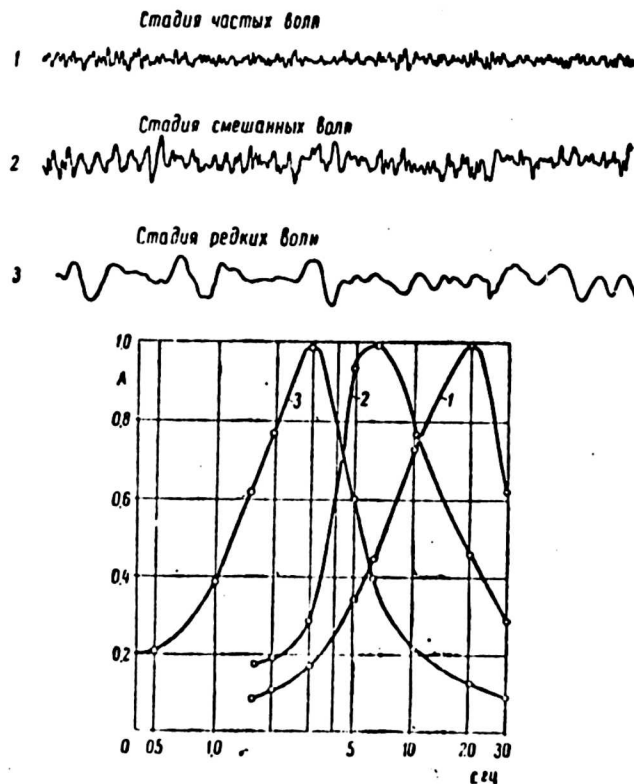


Fig. 2. EEG at various states of ether narcosis and their frequency spectra.