

SPECIAL ARTICLE

PRELIMINARY DATA ON EXPERIMENTAL ELECTRONARCOSIS INDUCED WITH APPARATUS OF THE SCIENTIFIC RESEARCH INSTITUTE OF EXPERIMENTAL SURGICAL APPARATUS AND INSTRUMENTS

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THE idea of using an electric current for narcotization of animals and man was conceived long ago. Our interest in the study of electronarcosis was to find a perfect method of analgesia which would possess the least toxic effect.

D'Arsonval (1890) and Leduc (1902) began work on this problem. The method of electronarcosis suggested by them was impracticable because it did not provide the anesthesia necessary for surgical operations, and was commonly accompanied by convulsive phenomena, apnea, and subsequent death of the animal. Therefore, subsequent work proceeded along lines of eliminating the convulsive phenomena with simultaneous inhibition of central nervous system functions and adaptation of the method to the practical needs of surgery.

Vasil'yev, Lapitskiy and Petrov (1937) see advantages of electronarcosis over ordinary narcosis because drug-induced narcosis develops slowly, disappears even more slowly, and leaves a prolonged after-effect. Therefore drug-induced narcosis is not very well subject to the control of the experimenter, whereas electronarcosis can depend entirely on the experimenter—it can be produced rapidly, maintained for any period of time and stopped at any time.

The theoretical foundation of electronarcosis was worked out chiefly by Russian scientists on the basis of the works of Sechenov, Vvedenskiy, Pavlov (Verigo, Peri, Samoylov, Chago-

vets, Vasil'yev, Lapitskiy, Petrov, Glazov, Kalendarov). They established the fact that electronarcosis, like ordinary narcosis, is essentially parabiosis.

Alvensleben (quoted by G. S. Kalendarov) used electronarcosis on man and came to the conclusion that "attempts to produce an unconscious state without a general convulsive state have not been successful to date." Cases are known (Glazov, 1947, and others) where electronarcosis sessions have been carried out on man and in which the current was increased to five milliamperes; this caused convulsions, while the pain sensitivity was practically unchanged and consciousness was maintained. There are also reports of attempts to use electronarcosis for obstetrical analgesia (Yakovlev and Petrov, 1938).

In the work by Gilyarovskiy, Sluchevskiy, L'eventseva and Kirillova (1948) it is reported that in the clinic of the Bashkir Medical Institute Shatov successfully performed an appendiceal revision in a patient under electronarcosis which lasted for 25 minutes. Complete anesthesia was noted. The authors do not give the technique of application of the electronarcosis nor the conditions of its use. Ivanov-Muromskiy (1953) reports that by using a pulsating current he obtained a state of complete electronarcosis which permitted him to carry out surgical procedures in animals. Makashev studied changes of blood during electronarcosis, and observed a slight and transient decrease in the red blood count and an increase in the white blood count. Lapitskiy, Petrov and Uspenskaya noted a slowing of the sedimentation rate directly related to the duration of action of the current.

Electronarcosis is also being studied widely abroad, although chiefly as an electroconvulsive instrument and for obtaining electric shock (Halpern and Peiser, 1953; Simon, Eger,

Translated from *Eksperimental'naya khirurgiya* (Experimental Surgery) 4: 3-7, 1957, for the National Institutes of Health Russian Scientific Translation Program by the U. S. Joint Publications Research Service.

Publication of this translation was suggested by readers interested in electronarcosis following the appearance of an abstract of the article (ANESTHESIOLOGY 20: 241, 1959).—Editor.

Bauman, 1953; Delgado, Alexander and Hamlin, 1953; Brockman, Matulevich, Sedlyachek-Komarovskiy, 1954; Beck, 1954; Sineskalki, 1953). Electronarcosis is being used extensively in combination with narcotic agents (Sarvit, Buresh, Bureshova, Petran', 1953; Cartie, Renaud, 1953; Caillard, 1954; Servit, 1954).

The majority of authors have used a unilateral pulsatile intermittent current, most often at a frequency of 100 periods a second with a ratio of duration of impulses to pauses of 1:8, 1:9, 1:10 and a current strength of six milliamperes (Leduc, Petrov, Yakovlev, Kalendarov, Lapitskiy and others). Glazov used electronarcosis in small dosages which did not produce the state of electronarcosis. A galvanic intermittent induced and sinusoidal current as well as a sinusoidal current in combination with an intermittent galvanic direct current were used for the electronarcosis. The arrangement of the electrodes was varied, but was chiefly bitemporal and fronto-lumbar. A bitemporal arrangement of the electrodes requires a current of greater strength for obtaining electronarcosis than the longitudinal arrangement (forehead to back, occiput to back).

Afanas'yev (1951) notes that the fronto-lumbar arrangement of the electrodes possesses an advantage over the bitemporal which often produces a marked psychomotor excitation. By using longitudinal galvanization (forehead to lumbar area) in 30 patients with various forms of schizophrenia, reactive psychoses and traumatic sequelae, the author obtained electronarcosis with sleep of different degrees. Here, the current was brought to the area of six milliamperes. The duration of sleep was up to several hours.

The essential defect of all apparatuses previously created, in which the subject is included in the plate circuit of output tubes, is the considerable change in the output voltage during the process of electrically-induced sleep and electronarcosis; this occurs as the result of a change in the resistance of the subject. This change is greater the higher the dose of current given to the subject. The defects indicated were eliminated in creating electric sleep and electronarcosis apparatuses in our

Institute (designed by the engineer, Khudyy).

The apparatus has the following distinguishing characteristics.

1. Along with the pulsatile current of rectangular shape a direct component galvanic current (pulsatile current in combination with direct) is passed through the subject in electronarcosis.

2. In the electronarcosis of animals (dogs) a composite pulsating voltage of the order of 37–40 volts was used; the average current strength was 7.4 to 13 ma. in combination with the direct component.

3. In the apparatus for electronarcosis the subject is hooked into the cathode circuit of the output tubes, which provides for constancy in the voltage administered to the subject, despite the change in the resistance of the subject with increase in the current dosage.

4. An electronic system was used in the oscillator which emitted rectangular impulses and made it possible to change the frequency from one to 130 periods per second with smooth regulation of the duration of the impulse.

5. The cathode-ray oscillograph in the apparatus provides for control of the shape and duration of the transmitted impulses.

6. An automatic device was used in the apparatus for the purpose of limiting the voltage in cases of defects in the apparatus, for which use was made of voltage regulators and an electromechanical relay which excludes the patient from the circuit under emergency conditions.

7. The plate voltage of the oscillator and of the main cascades is regulated by an electronic system.

8. The current regulation (average current) is carried out by various devices and by means of the oscillograph.

In all, we performed 128 experiments; some with a study of the physiological, biochemical and hematological indices of the condition of the animal organism and with the performance of various operations. In our experiments, the rectangular pulsatile current generated by the apparatus was at a frequency of 100 periods a second with an impulse to pause ratio of 1:8 or 1:10 in combination with the direct component. The electrodes of the cathode were

applied to the eyes; of the anode, to the occiput.

Operations under electronarcosis were carried out on dogs in 50 experiments, during which complete tissue anesthesia was obtained. Operations were performed in which soft tissues were dissected with the subsequent suturing of them in layers; excision of sections of soft tissue (skin and subcutaneous tissue); an autograft and amputation of an autografted extremity; laparotomy with revision of abdominal organs; application of a side-to-side anastomosis in the small intestine of a dog. In cases of deep electronarcosis the operations proceeded without any pain reaction on the part of the animals.

After the operations were concluded and the current turned off, tissue anesthesia was maintained, as a rule, for 10 to 30 minutes in the presence of a fully alert state of the dogs: they jumped off the table and began to eat heartily. Electronarcosis was repeated on the same animals from three to 12 times, often with such repeatedly used operations as laparotomy. One case of death was noted in a 10 year old dog during a repeated laparotomy at the time of the third electronarcosis experiment. Autopsy and histological examination showed marked venous congestion of the organs with perivascular diapedetic hemorrhages in the brain.

Our work convinced us of the possibility of obtaining deep anesthesia of tissues through the use of our apparatus for electronarcosis without side effects. Convulsions and apnea were not observed. Respiration of the dogs with high current dosages showed labored expiration or thermal dyspnea which coincided with the one- to two-degree increase in rectal temperature.

It is necessary that electric sleep during the first 10–15 minutes of the experiment with an average current of 0.6–0.9 ma. precede the exaltation phase in the animals (particularly the excited ones). In these cases, subsequent current dosages corresponding to the exaltation phase of electronarcosis (1.8–4 ma.) when gradually increased are layered onto the decreased functional lability of the cerebral cortex, which is in a state of diffuse sleep inhibition, as a result of which the excitation phase of the animal is either not manifested at

all or is smoothed over considerably. Thereby the threshold levels of electronarcosis are also changed. Deep skin anesthesia occurs earlier when electric sleep is used at the beginning of the experiment. With subsequent increase in the current an average level of anesthesia, permitting operation on the skin and superficial muscles, can occur at an average current of 6–7 ma., while sleep tissue anesthesia, permitting the performance of such operations as laparotomy and amputation of an extremity, etc., is achieved with a current strength of 9–12 ma.

We judged the transition of the excitation phase into the phase of narcotic inhibition by the occurrence of lack of sensitivity of the skin to a grossly painful stimulus and to the surgical procedure. In the majority of experiments with electronarcosis the systolic arterial pressure fluctuated from 5 to 10 mm. of mercury compared with the original. Similar blood pressure changes were observed in dogs in control experiments using sodium amytal narcosis. An analysis of the electrocardiograms obtained before and after electronarcosis shows a normal cardiac activity in the majority of experiments. In experiments with the manifest phase of excitation an increased excitability of the cardiac muscle may be presupposed, expressed in a shortening of the interval between systoles (P-P interval) and a reduction in the time of systole.

In cases of deep narcotic sleep we observed relaxation of the body musculature of the animals.

Blood examinations were made in 26 experiments (of these eight were associated with surgical procedures) performed on 11 dogs. The examinations showed that when optimum current doses are used for two hours no pathological changes are observed in the hemoglobin content, white blood count or red blood count. Repeated sessions of electronarcosis in dogs may in individual cases be associated with an increase in the white blood count by 2,000–8,000 and by a shift to the left in the leukocytic formula. In all experiments a normalization of the peripheral blood composition was observed usually the next day. The sedimentation rate is unchanged under the influence of electronarcosis.

Operations performed under electronarcosis are accompanied by blood changes identical with those which occur during operations under other forms of anesthesia. Electronarcosis does not produce marked changes in the blood prothrombin content nor in the coagulation time of the blood. It was not possible to establish any relationship in the thrombopoietic changes.

In performing the biochemical tests the first blood sample was taken after the physiological examination and application of the electrodes; the next, at the beginning of the development of the narcotic phase; then, after the animal had been in the narcotic state for 45 minutes, and before switching off the current. Afterwards, a sample was taken five minutes after turning off the current, two hours after the animal had rested, and on the following day.

At the beginning of the narcotic phase, a reduction in the blood sugar was found in nine out of 19 experiments; in two experiments no changes occurred, and in the remaining eight experiments an increase in the blood sugar level was observed. After the animal had been in the narcotic state for 45 minutes the blood sugar usually returned to normal. With subsequent turning off of the current, five minutes later the blood sugar level dropped, by comparison with preceding figures (that is, with the data obtained in the narcotic phase and with the original figures), in 10 out of 12 experiments. The maximum reduction of the blood sugar level noted was from 88 to 59 mg. per cent. Blood samples taken two and 24 hours after the electronarcosis session was carried out revealed a normal blood sugar content in the majority of cases.

The level of blood plasma proteins was subject to fluctuations both in the direction of an increase and of a decrease. Return to the original level occurred two to 24 hours after the electronarcosis session. The MacClure-Aldrich test, which characterizes the predisposition of the tissues to edema, showed a considerable increase in the rate of absorption of physiological solution which had been injected intracutaneously. This shortening of the absorption time reached 50 per cent of the initial level during the electronarcosis session. Examination showed that electronarcosis can produce considerable biochemical changes in

the blood. These changes were different under identical experimental conditions.

CONCLUSIONS

1. A pulsatile current with a frequency of 100 periods a second, a duration of one to 1.4 milliseconds in combination with a direct component, with an ocular-occipital arrangement of the electrodes (cathode on the eyes; anode on the occiput), an average current of 7–10 ma. and a voltage of 35–40 volts produces complete tissue anesthesia of animals, permitting the performance of complex surgical procedures.

2. Electronarcosis in dogs is obtained with a slow increase in the current. Over the course of 10–15 minutes the current is brought up to 0.9 to one ma., and thereby sleep is obtained in the animal. Then, the current is increased during the next 20 minutes to 4–5 ma. (for the purpose of obtaining the narcotic phase). With the start of the operation the current is slowly increased to 7–13 ma. (pulsating voltage of about 40 volts).

3. The data presented by us confirm the possibility of obtaining a deep anesthesia of tissues through the use of the electronarcosis apparatus of our Institute and the possibility of avoiding such side-effects as apnea, convulsions or mass movements. After the current is turned off, tissue anesthesia is maintained for 10–30 minutes.

4. The deep tissue anesthesia in electronarcosis permits the performance of operations such as laparotomy, amputation and grafting of an extremity, surgical procedures in the soft tissues of the animal, without any pain reactions by the animal.

5. It has been established by physiological, hematological and biochemical investigations that electronarcosis does not produce deep irreversible changes in the vital functions of the organism.

From the Scientific Research Institute of Experimental Surgical Apparatus and Instruments of the Ministry of Health, U.S.S.R.

BIBLIOGRAPHY

1. Afanas'yev, D. V.: *Vrach. delo* [Physician's Affairs], 1951, No. 3.
2. Vasilyev, L. L., Lapitskiy, D. A., and Petrov, F. N.: In the collection: "From Electric Current to Electronarcosis." *Friziol.*

- zhurn. S.S.S.R.* [Journal of Physiology U.S.S.R.], 1952, Vol. 38, No. 2.
3. Gilyarovskiy, V. A., Sluchevskiy, N. F., Liventsev, M. M. and Kirillova, Z. A.: *Klin. med* [Clinical Medicine], 1948, 26, 6, 18-23.
4. Glazov V. A.: *Nevropatol. i psikiatr.*, 1947, Vol. 16, No. 4.
5. Ivanov-Muromskiy, K. A.: *Vrach. delo*, 1953, 5.
6. Kalendarov G. S.: In the collection: "Electrical Narcosis." Published by V.I.E.M. [All-Union Institute of Experimental Medicine], 1937.
7. Lapitskiy D. A., Petrov F. P. and Uspenskaya N. A.: *Arkhi. biol. nauk.* [Archives of Biological Sciences], 1936-1941, No. XII, 1, 109-117.
8. Lapitskiy D. A., and Petrov F. P.: Collection: "Electrical Narcosis." Moscow, 1937.
9. Liventsev, N. M.: "A Study of Certain Reactions of the Organism to the Effect of a Pulsatile Current Acting on the Central Nervous System (Electronarcosis and Electric Sleep). Dissertation. Moscow, 1952.
10. Liventsev, N. M.: *Fiziol. zhurn. SSSR*, 1952, Vol. 39, No. 2.
11. Makashev, A. V.: *Veterinariya* [Veterinary Medicine], 1950, No. 1, 40.
12. Sereyskiy, M. A., and Rotshteyn, G. A.: *Nevropatol. i psikiatr.* [Neuropathy and Psychiatry], 1944, No. 6, pages 84-90.
13. Yakovlev, I. I., and Petrov, V. A.: *Akush. i ginekol.* [Obstetrics and Gynecology], 1937, No. 9.

OBSTETRIC ANESTHESIA From 1952-54 in England and Wales 32 of 49 maternal deaths were due to aspiration of vomitus under general anesthesia. Since then conduction anesthesia has been more widely used. Pudendal block has been satisfactory for all but the most difficult deliveries. When forceps were used and in breech extractions 439 hyperbarbic mupercaine spinal anesthetics have been given without serious neurological damage or fetal injury. The incidence of post spinal headaches was 14.1 per cent. (*Sears, R. T.: Use of Spinal Analgesia in Forceps and Breech Deliveries, Brit. M. J. 1: 755 (March 21) 1959.*)

TRICHLORETHYLENE In a four year study of obstetrical anesthetics at Frankford Hospital, 7,698 were conducted with trichlorethylene, nitrous oxide and oxygen, (87 per cent of the 9,135 deliveries during this period). Pertinent obstetric, pediatric and anesthesia data were recorded on punch cards and then an electronic sorting device was used to obtain this statistical information. Perinatal mortality and the need for resuscitation of the newborn was comparable with other series. There was no maternal mortality attributable

to anesthesia. Acceptability of nitrous oxide-trichlorethylene anesthesia by both doctors and patients was excellent (*Averbach, L. H., and others: Obstetric Anesthesia and Trichlorethylene, Nitrous Oxide and Oxygen, Obst. & Gynec. 14: 511 (Oct.) 1959.*)

COMPAZINE AND LABOR In a study of 140 obstetrical patients, 62 receiving Compazine and 78 receiving a placebo, onset of labor was not altered by prolonged administration of Compazine before admission to the hospital. The duration of obstetric labor and the time needed for the dilatation of the cervix were not significantly different in the Compazine and the placebo group. The attitude of patients under the effect of Compazine was carefree, phlegmatic, or lethargic, and the awareness of uterine contractions, primarily during prelabor, was lowered. On the basis of this combined clinical and laboratory study, it was concluded that Compazine delays patient awareness of uterine contraction but it does not have a direct effect upon the mechanism of labor or upon shortening the labor. (*Vasicka, A., and Kretschmer, H. E.: Effect of Prochlorperazine on Uterine Contractions, Obst. & Gynec. 14: 500 (Oct.) 1959.*)