EXPERIMENTAL STUDY OF COMBINED ELECTRONARCOSIS BY PULSE AND INTERFERENCE CURRENTS

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The attempts to use for electronarcosis a pulse current and sinusoidal and pulse current with the galvanic component did not lead to its wide adoption in practice. Many authors [1, 4, 5] noted in electronarcosis general muscular spasm, difficult respiration, an appreciable rise of arterial pressure, tachycardia, and attacks of motor excitation (hyperkinetic reaction). These complications limited the use of the method to experiments.

The advantages of electronarcosis—instantaneous achievement of analgesia, fine regulation, absence of aftereffects—compel us to continue searching for a type of current and method which would reduce to a minimum its undesirable side effects.

Low-frequency pulse currents cause painful sensations owing to the passage of the current through the skin and periosteum which are rich in nerve receptors. Currents of a higher frequency (4-7 kc) do not have such an unpleasant action, but they do not yield a sufficient effect. The phenomenon of interference makes it possible to produce in an object the effect of low-frequency oscillations by the addition of currents close in frequency and equal in amplitude.

We traced the change of certain functions of an organism in combined electronarcosis by pulse and interference currents. Using the method analogous to that used by N. M. Liventsev [2, 3] we compared the results of our experiments with the effects of electronarcosis itself.

METHOD

The experiments were carried out on 22 dogs. Electronarcosis was induced by square pulses and constant polarity with a duration of 0.5 sec at a frequency of 100 cycles. The arrangement of the electrodes was bitemporal.

A GIT-2 apparatus served as the generator of the interference current. As the characteristics of the interference currents for electronarcosis we selected the frequencies of the interfering alternating sinusoidal currents in the range of 4-5 kc with the possibility of detuning the frequency from zero to 220 cycles. The placement of each pair of electrodes was tempero-occipital.

Electronarcosis proper was accomplished by the action of pulse or interference currents without the injection of pharmacological agents. Combined electronarcosis by pulse or interference currents was carried out by the effect of the current against a background of drug anesthesia (thiopental sodium 3 mg/kg and listenon 0.3 mg/kg) with controlled respiration. After intubation the current was amplified up to 2.5-4 mA at an average value of the pulses, or up to 70-110 mA at the effective value under the action of interference currents (usual conditions of electronarcosis). Then the current strength was increased to 8-10 mA at an average value of the pulses (conditions of deep electronarcosis). Conditions of deep electronarcosis with interference currents were not accomplished.

Controlled respiration was carried out by a RPR volumetric respirator. We recorded respiration, heart rate, arterial and venous pressure (in the femoral artery and vein), rectal temperature, determined the coagulation time of blood by the Lee-White method, and recorded the EKG before and after anesthesia.

RESULTS

Immobilization of the animal by muscle relaxants with combined electronarcosis excluded the development of motor excitation in response to amplification of the current. Upon reamplification of the current when the effect of the next dose of muscle relaxants wore off and independent respiration was temporarily restored, the animals reacted only with brief (up to 15 sec) apnea.

At a current strength up to 1.5-1.8 mA we did not observe a rise of arterial pressure, increase in the amplitude of its pulse fluctuations, or an increase of the heart rate. At a current strength of 4 mA the arterial pressure averaged 190 ± 23 mm Hg and the heart rate was 122 ± 11 per min; at a current strength of 10 mA the values were respectively 228 ± 17 mm Hg and 134 ± 13 per min.

Twelve min after the start of the effect of the electrical current the arterial pressure dropped to 142 ± 21 mm Hg, its pulse fluctuations diminished, and the heart rate dropped to 102 ± 19. Subsequently, the arterial pressure and the heart rate did not substantially change.

The rate of current amplification determined the rate of the rise of arterial pressure and had little effect on its maximal level. A smooth continuous rise of current strength lowered the value of the rise of arterial pressure only by 10-15 mm Hg, and an amplification of current at 5-7 min intervals lowered it by 20-25 mm Hg.

The fluctuations of the venous pressure were less evident than those of the arterial pressure. The venous pressure, increasing by 29 ± 9 mm H_2O at a current strength of 10 mA in comparison with the initial value, changed negligibly thereafter before switching off the current.

The rectal temperature dropped by 2.7 ± 0.8° by the 3rd h of narcosis.

Upon switching off the current after the usual conditions of electronarcosis, respiration and the hemodynamic indexes were normalized within 10 min. After deep electronarcosis the period of coming out of it lasted not more than 30 min. On the EKG we noted an increase in the rate of the rhythm in comparison with the initial level, depression of the T wave in the III standard lead, and in one case sporadic extrasystoles.

For comparison with combined electronarcosis, indexes for electronarcosis proper are given. In the latter case, at a current strength of 1-1.2 mA the respiratory rhythm changed insignificantly. Dyspnea which was observed at a current of 1.5-2 mA was replaced at a current strength of 2.5 mA by quickened and deepened breathing, and at 4 mA and above by gradual inhibition of respiration up to its complete arrest at 6-8 mA.

When the current strength reached 0.5-0.6 mA, the arterial pressure rose to 180 ± 20 mm Hg, its respiratory and pulse fluctuations increased, and the heart rate rose to 140 ± 28 per min. At a current strength of 4 mA the arterial pressure reached 240 ± 27 mm Hg, at 10 mA it attained 290 ± 21 mm Hg, and the heart rate slowed down. Ten minutes after switching on the current the arterial pressure approached the initial level and remained elevated; tachycardia (up to 140 beats per min) persisted until the current was switched off.

Thus, in combined electronarcosis by a pulse current the increase of arterial pressure and heart rate is expressed less markedly and begins at higher values of current than in electronarcosis proper.

Various surgical interferences were carried out under combined electronarcosis and it was established that for operations on organs outside the abdominal cavity a current strength above 3 mA is needed, and for transecting the root of the lung and sectioning of the pericardium, 8-10 mA.

The period of residual analgesia after the usual conditions of electronarcosis does not exceed 7-10 min, whereas after deep conditions it lasted up to 45-50 min.

In all experiments we noted a drop in the extent of bleeding of tissues. Spasm of the peripheral vessels is considered to be the reason for this [2]. An investigation of the blood coagulation time showed an acceleration of this process in the 3rd h of narcosis by a factor of 4.8 in comparison with the initial data.

Thus, combined electronarcosis by a pulse current favorably differs from electronarcosis proper by the absence of hyperkinesis and a lesser rise of arterial pressure. The possibility of the gradual amplification of the current makes it possible to avoid an abrupt, dangerous rise of arterial pressure, and artificial ventilation ensures adequate respiration. However, the wide use of the method, as was already pointed out, is hampered by the appreciable fluctuations of the hemodynamic indexes and painful sensations upon passage of the current. Under deep conditions, the period of recovery from electronarcosis is drawn out.

Upon amplifying the strength of the interference current to 40 mA (with respect to the effective value) we did not note changes in respiration or cardiac activity. At 110 mA the number of heart beats increased to 112 ± 12 per min, the arterial pressure rose to 140 ± 8 mm Hg, its pulse fluctuations increased, venous pressure was elevated to 90 mm H_2O. Twelve min after the start of the effect the heart rate dropped to 96 ± 12, venous and arterial pressures were normalized, and the pulse fluctuations of the arterial pressure diminished.

Upon switching off the current the arterial pressure rose by 10-15 mm Hg, after which it dropped by 15-20 mm below the initial level. Normalization of respiration, arterial pressure, and heart rate occurred 8-10 min after switching off the current.

The rectal temperature and coagulation time of the blood did not reliably differ from those in narcosis by a pulse current (in both cases ($P > 0.05$).

At a current strength of 40 mA the degree of analgesia proved to be sufficient for preparing the femoral vessels, and at 110 mA for intra-abdominal operations: resection of the large and small intestine did not cause substantial changes in the hemodynamic indexes and pneumograms. Transection of the root of the lung and sectioning of the pericardium were accompanied by more evident changes than under deep conditions of narcosis by a pulse current: the venous pressure increased by 2.6, arterial pressure by 1.4, and the heart rate by 1.6 times, rectal temperature dropped by 0.6-0.7°. Residual analgesia after switching off the current in this series of experiments lasted not more than 7 min. The postoperative period was without complications.

Comparing electronarcosis by pulse and interference currents, we must note that the latter at a current strength of 40-50 mA yields the same analgesia as a pulse current with a strength of 2-2.5 mA. The permissible volume of surgical interferences under the effect of a pulse current of 3-4.5 mA or interference currents of 100-110 mA is the same. However, the shifts of the hemodynamic indexes under the effect of interference currents proved to be appreciably less. Deep conditions of electronarcosis by a pulse current (8-10 mA) permitted carrying out complex intrathoracic operations in the experiment.

This study gives us grounds to assume that after appropriate clinical tests combined electronarcosis by interference currents can find application in the clinic.

SUMMARY

A study was made on changes in the pulse rate, arterial and venous pressure, rectal temperature and time of complete blood coagulation in combined electrically induced narcosis with introductory administration of pharmacological drugs, myorelaxants and application of rectilinear pulse current.

In spite of a number of advantages (absence of convulsion, lesser increase in arterial pressure) combined electrically induced narcosis, just as electrical narcosis proper, is accompanied by considerable fluctuations in hemodynamic indices and painful sensation due to the passage of current. The latter circumstance has so far confined the use of this method to experiments.

The use of interference current for inducing narcosis has made it possible to alleviate considerably the negative phenomena involved in the use of currents of narcotic parameters.

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