CERTAIN CHARACTERISTICS OF THE ONSET OF NARCOTIC SLEEP IN THE FROG DURING INHALATION OF ETHER VAPOR FOLLOWING BILATERAL SEVERING OF THE VAGOSYMPATHETIC NERVE TRUNKS

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Notwithstanding its obvious importance in theory and practice, the question concerning the functional capacity of pulmonary tissue during inhalation narcosis has, up to the present, been greatly neglected. Thus, for example, in the works of several authors, the effect of ether vapor on the lungs has been assessed only from the point of view of its action on the pulmonary vessels and the vascular network of the lungs [10, 13-17]. Besides, very little attention has been devoted to the permeability of the alveolar-capillary complex to narcotic substances. Consequently, it is of considerable interest to examine the different speeds at which certain substances pass from the alveolar air into the blood and their dependence on the condition of the central nervous system of the animals under test [7, 18].

Unlike the homiothermic animals, in which the lungs are innervated by the vagus, sympathetic and spinal nerves and also by branches from the diaphragmal nerve [9, 10], the innervation of the lungs in poikilotherms is only through the sympathetic and parasympathetic fibers which run in one common trunk, called the vagosympathetic nerve [11, 12]. However, it should be borne in mind that the bilateral severing of these trunks, in all probability, does not completely isolate the lungs from the central nervous system, since it does not exclude the possibility of impulses arising along the nerve fibers of the vessels of the pulmonary vessels, the larynx, and the pleura.

In the present work a study has been made on the speed at which narcotic sleep sets in, in intact and in partially denerved frogs.

EXPERIMENTAL METHOD

Our method of "denerving" frogs was carried out as follows. Under light ether narcosis, a cut was made in the frog's skin along the middle line of the ventral surface from the anterior edge of the lower jaw to the end of the thorax. All the soft tissues were gently separated and the vasculoneural bundles on both sides, in the area between the large cutaneous artery, pulmonary artery, cutaneous-pulmonary artery and jugular vein, were laid bare. The vagus nerves and the long laryngeal nerves running in their immediate vicinity were located. The vagus nerves were severed in the immediate proximity of the pulmonary sacs, near the place where the arteries, veins, and soft tissues, which are found here, form an obtuse bifurcation, that is, considerably below the point where the long laryngeal nerve emerges from the common nerve trunk. Special attention was paid to the careful carrying-out of the operation and to hemostasis. Subsequently, a 2-way tube, connected to an artificial respiratory apparatus [1, 2], was inserted in the respiratory cleft. The open cut was plugged with cotton wool moistened with Ringer's solution. The frog was firmly fixed by the forelegs and head to a preparation table. One of the hind legs was connected to a lever for recording its movements on a kymograph. During the course of the experiments a painful stimulation was applied to the skin of this leg with the aim of causing a reflex action. In this way observations were carried out on the depth of narcosis. All the manipulations described above, up to the cutting of the skin and exposure of the vasculo-neural bundles, were carried out on control frogs, but the nerves were not cut.

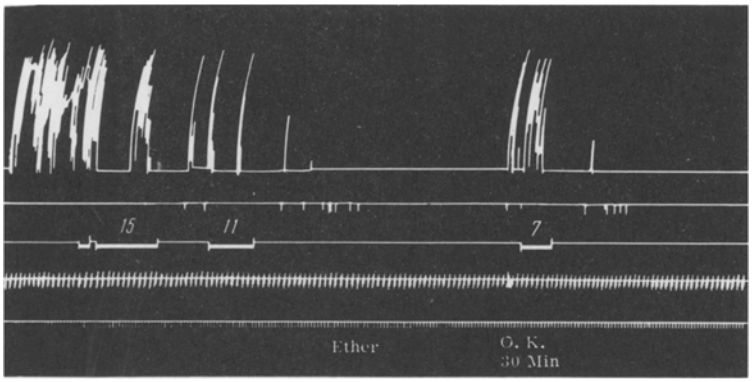

Fig. 1. Kymogram showing the onset of narcotic sleep in frogs with intact lungs (narcosis—15 + 11 = 26 "volumes" of ether vapor). a) Movements of hind leg; b) trace showing skin stimulation; c) trace showing beginning and end of injection of ether vapor into the lungs; d) frequency of respiration; e) time intervals (2 sec); O. K. 30 min) stopping of kymogram after 30 min.

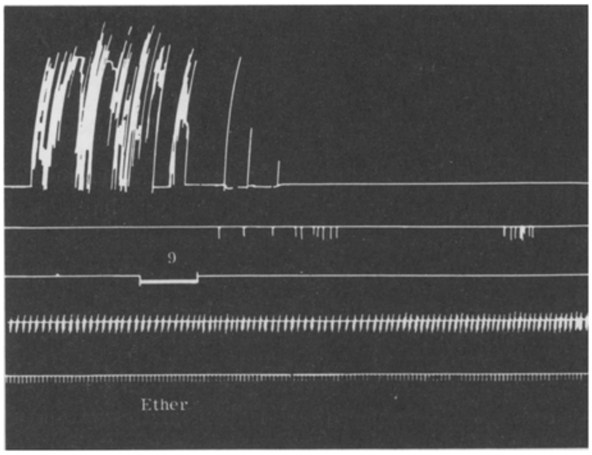

Fig. 2. Kymogram showing the onset of narcotic sleep in frogs with vagotomized lungs (narcosis—nine "volumes" of ether vapor). Symbols as in Fig. 1.

Forty-three experiments in all were carried out, 23 on frogs having the vagosympathetic trunk intact and 20 on animals with denerved lungs. Observations on frogs on which bilateral vagotomy had been performed without repeated injection of ether vapor into the lungs are not included here. These experiments showed that, for $1\frac{1}{2}$ h after recovery from narcosis, such frogs differed in no way from the controls in which the lungs were intact.

EXPERIMENTAL RESULTS

The frogs usually began to recover from narcosis 25-30 min after the operation and, when stimulated, they responded by movements of the legs. In approximately 40-60 min the animals had recovered completely and tried to free themselves by continuous movements of the hind legs. We then proceeded to carry out the main experiment which consisted in passing ether vapor through the lungs with the help of the artificial respirator. In 25-35 sec this gave rise to a sharp, motor excitation lasting for 10-25 sec in frogs having intact vagus nerves. Subsequently, this effect ceased and was replaced by complete immobility of the animal. However, on being stimulated, the frog still continued to react for 1-3 min. Deep narcotic sleep followed for which not less than 20-40 "volumes"* of ether vapor were required (Fig. 1). The average duration of the sleep was 30-40 min during which the lungs were continuously ventilated with fresh air.

If the frog was treated repeatedly with ether when only partial recovery from narcosis had taken place (animal responded to stimulation by single movements of its leg), this again caused a rapid onset of transient excitations (8-15 sec) followed by deep sleep. In all, only 7-12 "volumes" of ether vapor were required to produce this effect.

If ether vapor was introduced into the lungs of frogs in which bilateral section of the vagosympathetic trunks had been carried out then, unlike the picture described above, a very transient phase of excitation quickly set in for 6-14 sec and, judging from the extent of the movement, proved to be considerably weaker than that observed in the frogs of the first series of experiments (controls.

Already after 10-12 "volumes" of ether vapor, that is, in $1\text{-}1^{1}/_{2}$ min following the beginning of inhalation, no response was made by the frogs when the leg was stimulated (Fig. 2). However, despite such a small amount of ether being required to produce deep narcotic sleep in the frog, this state lasted the same length of time as in the frogs of the first series of experiments (not less than 30-40 min).

Thus, by a comparison of the data obtained, it is not difficult to see that bilateral cutting of the vagosympathetic trunks leading to the lungs brings about a reduction of the latent period between the introduction of the narcotic into the lungs and the onset of the phase of excitation, to a considerable curtailing of the time to the onset of narcotic sleep and, lastly, to a considerable reduction in the amount of narcotic necessary for inducing the deep state of narcosis.

Our preliminary work [2-6] on the study of the effects of ether vapor on the vascular network of the lungs and on their capacity for diffusion indicates that ether narcosis, as well as the exclusion of the central nervous system, substantially alters the permeability of the alveolar-capillary complex.

From the data given above it can be presumed that the permeability of the lung membrane for ether vapor is increased by eliminating the vagosympathetic innervation of the lungs.

SUMMARY

In frogs with severed vagosympathetic trunks narcotic sleep during ether vapor inhalation set in earlier, while the excitation phase was earlier and shorter than in frogs with intact lungs. At the same time, the duration of sleep was equal in both, whereas ether expenditure was much larger in the latter.

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* The word "volume" should be understood to mean one delivery and one suction movement of the artificial respiratory apparatus supplying air containing a known concentration of ether vapor to the lungs.

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