Elimination by Hypoxia of Cerebral Blood Flow Autoregulation and EEG Relationship

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Summary. 1. The relationship between cortical blood flow and the frequency content of the EEG was studied in a circumscribed area of the exposed cerebral cortex in cats under nitrous oxide-oxygen anaesthesia. Autoregulation of the cortical blood flow was also tested during step-changes of the arterial blood pressure. Observations were made before and after an episode of severe hypoxia.

2. An episode of systemic hypoxia disrupted the normal high correlation between cortical blood flow and EEG frequency content. In the post-hypoxic period cortical flows of up to about three times normal values were recorded together with brain swelling and a slow wave EEG. The hyperemia and swelling subsided during 1—2 h after the hypoxic episode, and were accompanied by partial or complete recovery of the EEG. In the post-hypoxic period a defective autoregulation of the cortical blood flow to changes in the systemic blood pressure was demonstrated.

3. The cerebral post-hypoxic state with hyperaemia, brain swelling, EEG depression, and loss of autoregulation of blood flow, is probably caused by an accumulation of anaerobic metabolites which lead to cerebral tissue acidosis.

Key Words: EEG frequency — Regional cortical blood flow — Isotope measurements — Effects of hypoxia — Cat

Introduction

For the brain in a normal physiological state, there is a high correlation between the frequency content of the EEG and the rate of regional cerebral blood flow (rCBF) both in animals (INGVAR et al. 1965) and man (INGVAR and SULG 1967). This relationship is particularly evident when the two parameters are measured simultaneously in the same cortical region (BALDY-MOULINIER and INGVAR 1967). It supports the hypothesis that rCBF is normally adapted to the metabolic activity of the nervous tissue within the region (SCHEIDT 1950, LAASSEN 1959, KETY 1956), which is also related to the frequency pattern of the EEG (GLEICHMANN et al. 1962). Moreover, in normal conditions, the cerebral blood flow — both for the whole brain, and regionally — is maintained constant despite variations in the systemic blood pressure over a wide range. This is due to the so-called autoregulation (FOG 1934, HÄGGENDAL 1965, HARPER 1965, LAASSEN 1966). Thus, at constant cerebral metabolism, the nervous tissue is supplied by a constant blood flow despite variations in the perfusion pressure.

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It was observed, however, that the normal rCBF-EEG relationship did not hold for animals in poor condition (Baldy-Moulinier and Ingvar 1967) nor in cerveau isolé-preparations with brain oedema (Freeman and Ingvar 1966). In such animals a slow wave EEG was found to be associated with a high cortical blood flow, when compared with animals in good condition within the same range of arterial pCO₂. These observations suggested that an episode of cerebral hypoxia might 'uncouple' the normal correlation between rCBF and EEG. Moreover, since cerebral blood flow autoregulation is also severely impaired during hypoxia (Häggestål and Johansson 1965), it seemed possible that this impairment might be present when the rCBF-EEG correlation was lost after a hypoxic episode.

In the present experiments we have studied the effects of severe systemic hypoxia upon the rCBF-EEG relationship in the cerebral cortex of cats. Nitrous oxide-oxygen anaesthesia was selected to maintain only light anaesthesia and also to avoid a possible protective effect of barbiturates on the brain against hypoxia (Wilhelm 1966). After observing the recovery of the cerebral circulation from the hypoxic episode as judged by the cortical blood flow and EEG, the ability of the cortical circulation to autoregulate was tested by changes in the arterial blood pressure.

**Materials and Methods**

Thirteen successful experiments in cats weighing 2.3—3.9 kg were performed. Anaesthesia was induced without an active stage of excitement by adding ether to a glass chamber containing the cat. All animals were then immediately tracheotomized and artificially ventilated with 20% oxygen in nitrous oxide, using intermittent intravenous gallamine triethiodide (Flaxedil) as muscle relaxant. The ventilatory volume was adjusted to maintain an arterial pCO₂ of about 30 mm Hg, which is the normal value for the awake cat (Fink 1962).

The femoral arteries and a vein were cannulated for arterial blood sampling, blood withdrawal, measurements of blood pressure by means of an electromanometer (Elema-Schöndand), and for intravenous injections and blood replacement. Arterial pCO₂ was measured by means of the Astrup technique. Body temperature was measured rectally and maintained steady by means of an electrical heating pad.

The blood flow of the exposed cerebral cortex (rCBF) was determined by the isotope clearance method, using a rapid bolus intra-arterial injection of ⁸⁸Krypton-saline described in detail by Bertz et al. (1966). The cortex of the suprasylvian gyrus was exposed by a craniotomy around which four brass electrodes for bipolar EEG recordings were screwed through the skull. Continuous records of the EEG and arterial blood pressure were made by means of an 8-channel Offner EEG machine, using paper speeds of 1 or 50 mm/sec and a time constant of 0.1 sec. Artefact-free 10-sec epochs of the EEG, taken during the first 2 min of the rCBF-determinations, were analyzed manually to yield their "EEG frequency index" (mean frequency) for the range 1—25 c/sec (Ingvar et al. 1965, Sulg 1968, Baldy-Moulinier and Ingvar 1968;