EFFECT OF γ-AMINOBUTYRIC ACID ON SOME PHYSICOCHEMICAL PROPERTIES OF ARTERIAL BLOOD

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γ-Aminobutyric acid (GABA) causes a statistically significant increase in pCO_2, the total CO_2 concentration and the concentration of bicarbonates in arterial blood, while lowering the pH and negative base excess of whole plasma and blood. The remaining indices showed no statistically significant changes. GABA evidently has the property of action on the respiratory component of the acid-base balance of arterial blood. This must be taken into account when mechanisms of its effect on the cerebral hemodynamics are explained.

It has recently become clear that the cerebral blood vessels are extremely sensitive to changes in the physicochemical properties of the blood and that these play an important role in regulation of the cerebral hemodynamics. The most important factors concerned are the CO_2 and oxygen pressures in the arterial blood and the hydrogen ion concentration of the cerebrospinal fluid [5-7, 10, 11, 14].

Another fact which deserves attention is that γ-aminobutyric acid (GABA), which is present in high concentrations in the brain tissues [4, 8, 15] and vessels [3] in mammals, has the property of increasing the cerebral blood supply [1, 2].

The object of the present investigation was to study the effect of GABA on some physicochemical properties of arterial blood in cats.

EXPERIMENTAL METHOD

Experiments were carried out on 14 cats anesthetized with urethane (0.5 g/kg body weight) and chloralose (50 mg/kg). GABA was injected via the femoral vein in a dose of 1 mg/kg. The physicochemical parameters were studied in a control sample of arterial blood taken beforehand and in samples taken 2 and 10 min after the injection. Samples of arterial blood were taken with a thin polyethylene catheter introduced into the carotid artery, under anaerobic conditions produced by filling the dead space of the syringe with heparin solution.

The pH of the arterial blood was determined by glass (type G-202-C) and calomel (type K-401) electrodes. The emf produced between them was measured by a pH-meter (Radiometer, Denmark).

The pO_2 was measured by means of an oxygen electrode of Clark's type, consisting of a platinum cathode 20 μ in diameter and an Ag−AgCl anode. The active surface of the electrode was separated from the blood sample to be tested by a polypropylene membrane.

The CO_2 pressure was measured by a Severinghaus electrode, consisting of a modified pH-electrode which can be used to determine the pH of an electrolyte between a sensitive glass surface and a thin Teflon membrane, permeable to CO_2. Equilibrium of CO_2 was reached after 1 min, and the output signal of the electrode, calibrated relative to gases of known partial pressure, indicated the pCO_2 on the blood sample.

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TABLE 1. Effect of GABA on Physicochemical Properties of Arterial Blood

Index	Control	After injection of GABA, 1 mg/kg	
		2 min	10 min
pO_2, mm Hg	75,25±1,23	73,75±3,27	73,25±2,95
pCO_2, mm Hg	28,78±1,49	39,50±4,22[1]	35,57±2,87*
pH	7,30±0,02	7,25±0,01	7,22±0,02*
O_2 saturation, %	92,79±0,91	91,02±1,29	93,70±0,88
ABE, meq/liter	−12,25±0,60	−11,43±0,26	−10,58±0,43*
Plasma BE, meq/liter	−12,31±0,79	−11,02±0,44	−10,13±0,41*
Actual HCO_3, meq/liter	13,09±0,69	15,08±0,63[1]	16,28±0,95*
Standard HCO_3, meq/liter	15,29±0,75	15,67±0,27	16,81±0,64
Total CO_2 (in mmoles/liter) of plasma	14,12±0,73	16,90±1,28	18,06±1,08[1]
Buffer bases, meq/liter	33,42±1,00	34,63±0,37	36,17±0,93

*Statistically significant changes ($P < 0.05$)

The oxygen saturation was calculated from a Severinghaus nomogram corrected for temperature and pH. The base excess of whole blood (ABE—actual base excess) and of the plasma (plasma BE), and also the concentration of bicarbonates in the blood (actual HCO_3) and plasma (standard HCO_3) and the total CO_2 were determined by means of the compensating nomogram of Siggaard-Andersen [13]. Buffer bases were calculated by the formula: buffer bases = 41.7 + 0.42 · Hb + BE (completely oxygenated). The base excess of completely oxygenated blood was calculated from the formula: Be (completely oxygenated blood) = $\frac{\text{ABE} - 0.3\text{Hb} \cdot (100 - \text{oxygen saturation})}{100}$. The hemoglobin concentration was determined by Sahli's method.

All the values obtained were corrected for body temperature.

RESULTS

A statistically significant increase in pCO_2 of the arterial blood, by 37.2%, was found 2 min after intravenous injection of GABA. The effect was slightly diminished 10 min after injection, but pCO_2 continued high compared with the control value of 23.5%.

Under the influence of GABA the pH of the arterial blood was lowered. For example, 2 min after injection its pH was lowered by 0.7% compared with the control, which is not statistically significant, but after 10 min the decrease in pH was statistically significant (by 1.1%).

A tendency was found for the actual base excess and the plasma base excess to decrease after injection of GABA. These changes were not statistically significant 2 min after injection (6.7 and 10.5%, respectively, compared with the control), but were significant after 10 min (13.7 and 17.8%).

GABA increased the blood bicarbonate concentration by 15.2% 2 min after injection, increasing to 24.3% compared with the control after 10 min.

Under the influence of GABA the total CO_2 concentration was increased: by 19.7% over the control level after 2 min (not statistically significant) and by 27.9% after 10 min (statistically significant).

The value of pO_2 was reduced by 1.9% 2 min after injection of GABA, and by 2.6% 10 min after injection (not statistically significant).

The oxygen saturation also showed a tendency to decrease 2 min after injection of GABA, namely by 1.9% compared with the control (not statistically significant). However, 10 min after injection it had completely recovered and was actually higher than initially.

GABA increased the plasma bicarbonate concentration by 2.5% 2 min after injection and by 9.9% 10 min after injection (neither is statistically significant).

The increase in buffer bases (by 3.6% after 2 min and by 8.2% after 10 min) likewise was not statistically significant.

Analysis of the experimental data shows that GABA exerted a marked effect on the level of one of the chief components of the acid-base balance concerned in the mechanism of regulation of the cerebral blood flow—on pCO_2.

The increase in pCO_2 was accompanied by a statistically significant decrease in pH (acidification of the arterial blood) and by an increase in the total CO_2.

The small decrease in negative base excess of the blood and plasma observed 10 min after injection of GABA was statistically significant. This, together with the statistically significant increase in blood bicarbonate concentration, is evidence of compensatory changes aimed at maintaining the decreasing pH. This also indicates the ability of GABA to influence the metabolic component of the acid-base balance to some degree [9].

As Table 1 shows, GABA had no marked effect on the plasma level of buffer bases and bicarbonate, the chief parameters of the metabolic component of the acid-base balance [12].

The results of this investigation can be summarized in the conclusion that assessment of the mechanisms whereby GABA exerts its influence on the cerebral hemodynamics must take into account its ability to effect the respiratory component of the acid-base balance of arterial blood.

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