THE ACCURACY OF THE MICRO-DETERMINATION OF THE P_{CO_2} OF BLOOD FROM THE EAR-LOBE

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INTRODUCTION

In a micromethod[1] for the determination of the P_{CO_2} of arterial blood, the P_{CO_2} is calculated from pH determinations before and after equilibrating whole blood with gas mixtures of known CO_2 content. Blood is drawn from the ear-lobe into capillary tubes containing dry heparine and sodium fluoride. The authors found a difference of 2 mm between the P_{CO_2} of arterial blood and blood from the ear-lobe. We have arterialised the ear-lobe before taking blood from it and have compared the P_{CO_2} with the arterial P_{CO_2}. In order to establish the accuracy of the micro P_{CO_2} method, we have performed the micro-determination on blood of known P_{CO_2}.

PRINCIPLE

The relationship between the pH and the log P_{CO_2} of blood is linear in the range investigated. The slope of the pH – log P_{CO_2} line depends on the haemoglobin content of the blood and the position of the line in the diagram is determined by the bicarbonate content. After equilibration of the blood with two gas mixtures of known CO_2 concentration the slope and the position of the line are known. On this line the actual P_{CO_2} of the blood is found if the actual pH of blood is known. The accuracy of the method can be established by determining in the same way the P_{CO_2} of blood of known P_{CO_2}.

APPARATUS

Measuring equipment

The same equipment as described in a previous communication[2] was used, including a pH-meter type pH 22 with external meter pH 6–8, a micro glass electrode G.S. 278 and a calomel electrode K 100 (Radiometer Copenhagen). All measurements were performed at 37.5°.

Tonometer

The equilibration apparatus differs from that used by ANDERSEN *et al.*[1] in that a third compartment for the equilibration of 0.5 ml blood is present (Fig. 1).

Agitation of the blood is obtained by placing the tonometer on a movable steel plate which is caused to vibrate by the action of an electromotor placed on the same plate and turning an excentric cam. With a variable transformer the speed of the

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motor is regulated till the blood spreads on the inner walls of the tonometer. Water at 37.5° from a circulation thermostat is introduced at A and C, and drained at B. The equilibrating gas mixture after saturation with water vapour at 37.5° flows through thermostatted tubes to the tonometer.

Gas mixtures

Mixtures of CO_2 and air, containing about 4, 5.5 and 8% CO_2 compressed into gas cylinders were used. The CO_2 concentration was determined by Haldane analysis. The Haldane apparatus had previously been calibrated by weighing out with mercury. Moreover the accuracy of the determination was checked occasionnally by the analysis of gas mixtures prepared by means of mixing pumps having an error of less than 0.5 ‰. The standard deviation was $\pm$ 3 ‰.

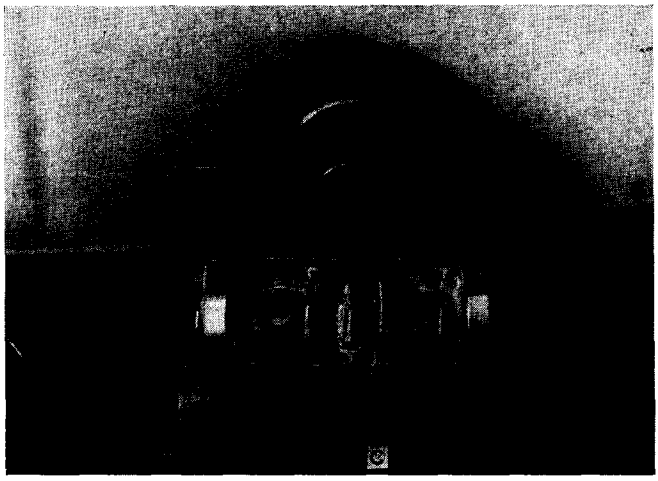

Fig. 1. Equilibration apparatus.

PROCEDURE

Blood sampling

Hyperaemia of the ear-lobe was acquired by rubbing with Trafuril paste (Ciba). Arterialised blood was sampled in heparine-fluoride filled capillary tubes. Blood from the brachial artery was obtained by puncture with a Cournand-needle. Further details have been described previously[2].

pH measurement of blood

The electrode circuit and the pH-meter were checked with two phosphate buffers of pH 6.835 and pH 7.375 each at 37.5°. The glass electrode was rinsed with distilled water and isotonic saline before and after the determination of blood pH. After each measurement a possible drift was detected with the buffer of pH 7.375.

Equilibration of the blood

The compartments A and C of the tonometer were filled with blood from two capillaries or from the syringe when arterial blood had been taken. 15 min before

equilibration the gas stream of the CO_2 mixtures saturated with water vapour was started. The blood in contact with the gas mixtures was vibrated for 4 min and then the pH of each sample was measured. For the determination of the accuracy of the micro P_{CO_2} method 0.5 ml blood was equilibrated in compartment B for 5 min and then the same procedure was applied to this blood.

Calculating the P_{CO_2} of blood

The P_{CO_2} of the gas mixtures was calculated daily using the following equation.

$$P_{CO_2} = \frac{\%\ CO_2}{100}\,(P_B - P_{H_2O})$$

where P_B is barometric pressure (mm Hg) and P_{H_2O} is the saturated water vapour pressure at 37.5° (49 mm Hg). The P_{CO_2} of the blood was calculated from

$$P_{CO_2} = \log(P_B - 49)/100 + \log a_1 - \{(pH_2 - pH)/(pH_1 - pH_2)\}\,(\log a_1/a_2)$$

where a_1 = % CO_2 gas cylinder 1; pH_1 = pH of blood with pCO_{2_1}
a_2 = % CO_2 gas cylinder 2; pH_2 = pH of blood with pCO_{2_2}

RESULTS

The P_{CO_2} of blood from the ear-lobe compared with the pCO_2 of arterial blood

Blood was taken simultaneously from the ear-lobe and the brachial artery in 20 patients. The results are given in Table I.

TABLE I

P_{CO_2} OF BLOOD FROM THE EAR-LOBE AND FROM THE BRACHIAL ARTERY

No.	P_{CO_2} *blood artery*	P_{CO_2} *blood ear-lobe*	P_{CO_2} *blood artery* − P_{CO_2} *blood ear-lobe*
1	38.6	37.8	+0.8
2	40.8	39.1	+1.7
3	33.6	33.6	0.0
4	52.1	52.5	−0.4
5	45.7	43.9	+1.8
6	41.6	41.6	0.0
7	38.5	39.9	−1.4
8	38.0	36.7	+1.3
9	43.0	43.0	0.0
10	44.0	46.4	−2.4
11	43.8	45.0	−1.2
12	42.2	41.6	+0.6
13	37.7	38.0	−0.3
14	38.0	36.7	+1.3
15	42.1	43.4	−1.3
16	36.8	35.7	+1.1
17	41.0	40.4	+0.6
18	36.8	36.5	+0.3
19	37.9	37.9	0.0
20	41.2	40.3	+0.9

$\bar{X}$ = +0.16 mm Hg
S.D. = ± 1.2 mm Hg.

Accuracy of the micro P_{CO_2} determination

0.5 ml blood of each of 20 patients was equilibrated with a gas mixture of known P_{CO_2}. The measured P_{CO_2} of the equilibrated blood was compared with the P_{CO_2} of the gas mixture. Results are given in Table II.

TABLE II

P_{CO_2} OF EQUILIBRATED BLOOD COMPARED WITH THE P_{CO_2} OF THE EQUILIBRATING GAS MIXTURE

No.	P_{CO_2} *gas mixture*	P_{CO_2} *blood determined*	P_{CO_2} *gas mixture* — P_{CO_2} *determined*
1	45.8	45.1	+0.7
2	45.5	46.1	−0.6
3	45.1	44.9	+0.2
4	44.6	44.6	0.0
5	43.8	43.1	+0.7
6	43.6	43.7	−0.1
7	43.6	43.0	+0.6
8	41.1	41.2	−0.1
9	41.1	42.4	−1.3
10	41	41.2	−0.2
11	41	41.7	−0.7
12	41	40.8	+0.2
13	41.5	43.1	−1.6
14	41.8	41.3	+0.5
15	41.8	41.2	+0.6
16	41.8	40.8	+1.0
17	41.3	40.3	+1.0
18	41.3	41.5	−0.2
19	41.6	41.8	−0.2
20	41.8	42.7	−0.9

$\bar{X}$ = −0.02 mm Hg
S.D. = ± 0.7 mm Hg.

DISCUSSION

The P_{CO_2} of blood from the hyperaemic ear-lobe appears to be equal to the arterial P_{CO_2}. ANDERSEN *et al.*[1] found that the P_{CO_2} of blood from the ear-lobe was 2 mm Hg lower than that of arterial blood. As the only difference between our method and theirs is the blood used from the arterialised ear-lobe, the difference of the results obtained must be explained by assuming that the blood used by them was not fully saturated.

The micro-method for the determination of P_{CO_2} appears to have a standard error of about 2%. This value agrees with the value expected by ANDERSEN *et al.*

SUMMARY

The P_{CO_2} of blood from the hyperaemic ear-lobe equals the arterial P_{CO_2} within the limits of experimental error. The standard error of the micro method is 2%, the mean difference between blood from the ear-lobe and arterial blood is −0.5%.

REFERENCES

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