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Changes in Carbon Monoxide Content of Whole Blood during Gas Equilibration in the Radiometer Dissociation Curve Analyzer (DCA-1)

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ABSTRACT

The COHb content of whole blood was determined by two different methods during gas equilibration in the Radiometer Dissociation Curve Analyzer (DCA-1). There was a slight but significant decrease in the values during the equilibration procedures. For most purposes a single measurement of the blood COHb content before or after the procedure is sufficient. However, when very accurate data are needed, repeated determinations are recommended.

Determinations of whole blood oxygen affinity over the whole oxygen saturation range are most conveniently performed by the procedure described by Duvelleroy et al. (1970) utilizing for example the apparatus DCA-1 (Radiometer, Copenhagen, Denmark) (cf. also Bellingham & Lenfant, 1971). In this method, the blood is tonometred with nitrogen and a known volume of this deoxygenated blood is equilibrated with a known volume of oxygen. During the equilibration with oxygen, the P_{O2} in the gas phase and in the blood is recorded continuously. The change in the gas P_{O2} is proportional to the change of blood oxygen content.

Since the blood concentration of carbon monoxide affects the oxygen affinity, it is necessary to know the carboxyhaemoglobin content (COHb) during the whole equilibration procedure. We report here results of measurements of the COHb concentration in whole blood before and after deoxygenation and after oxygenation during actual determinations of the oxygen affinity in the DCA-1 apparatus.

METHODS

Fresh heparinized whole blood from 17 healthy donors, smokers and non-smokers, was used. After the blood sample was drawn the initial COHb concentration was determined. 8.5 ml of the blood was transfered into the DCA-1 apparatus and the deoxygenation was done with nitrogen gas containing 5% carbon dioxide, at a constant flow rate of about 30 ml per minute and at a constant stiring rate (2 000 rpm) of the blood. When the blood was completely deoxygenated, i.e. after 30 to 40 min, a second sample was taken for COHb determination. The oxygenation of the blood was started and when 100% saturation was reached (after 15 to 25 min) a third COHb determination was done.

Increased COHb levels in blood from non-smokers were obtained by adding *in vitro* various amounts of the same blood saturated with carbon monoxide. Decreased COHb levels were attained in the blood of smokers by smoking abstinence for 18 hours prior to the measurement.

The COHb concentration was determined by the method of Dahlström (1960), as modified by Gassmann & Wranne (1967), and spectrophotometrically in the IL 182 instrument (IL Inc. Lexington, Mass., USA) according to the manufacturer's manual.

The results of the COHb determinations of the blood, made with the two methods, in the different steps during the run, were tested with Student's *t*-test for paired observations.

RESULTS AND DISCUSSION

The results of the measurement of COHb using both methods on fresh blood from smokers, non-

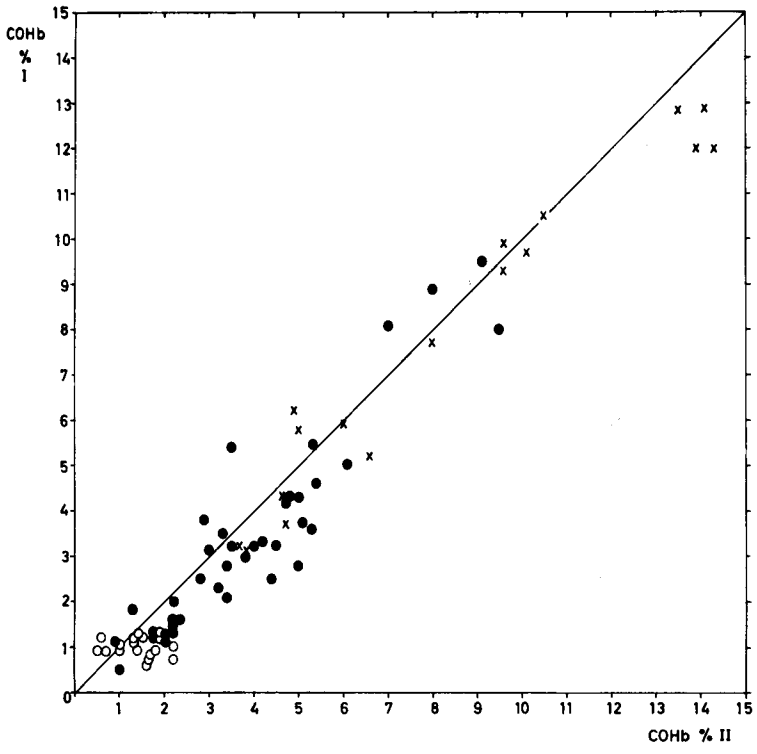

Fig. 1. Results of simultaneous measurements of the COHb content of whole blood by the method of Dahlström (I) and the spectrophotometric determination with CO oximeter IL 182 (II). ○ = non-smokers, ● = smokers, × = non-smokers with CO added.

Table I. *Changes in COHb during deoxygenation and oxygenation in the Radiometer DCA-1 apparatus*

Expt. No.	NS = Non-Smoker NS + CO = CO added S = Smoker	Before deoxy-genation	After deoxy-genation	After oxy-genation
399	NS	0.6	1.8	1.0
401	NS + CO	13.0		14.0
402	NS	0.9*	0.8*	0.7*
403	NS + CO	10.5*	9.9*	9.8*
408	S	3.5*	3.4*	4.4*
409	S	5.0*	4.9	4.7*
410	NS	1.2*	1.4	1.0*
411	NS + CO	14.0*	15.0	13.2*
412	NS	1.7	1.5	1.4
413	NS + CO	17.1	16.8	16.6
414	S	1.5*	1.5	1.5*
415	S	4.5*	3.5	3.8*
422	NS	1.1*	1.5	1.4*
423	NS + CO	4.2*	4.8	4.5*
416	NS	1.2*	1.1	1.2*
417	NS + CO	13.5*	13.6	12.9*
418	NS	1.6*	1.0	1.3*
419	NS + CO	9.5*		7.9*
424	NS	1.6*		1.2*
425	NS + CO	5.9*		5.9*
404	S	1.7*	1.6*	1.6*
405	S	3.9*	3.0	3.4*
406	S	1.5*	0.9	1.3
407	S	3.4*	3.0	3.4
420	NS	1.6*	1.2*	1.0*
421	NS + CO		13.0	13.3*
426	NS	1.3*		1.5*
427	NS + CO	5.4*		5.5*
428	NS	1.2*		1.0*
429	NS + CO	3.5*		3.5*
430	S	3.8*		3.8*
431	S	9.3*		8.4*
432	S	4.4*		4.5*
433	S	8.7*		7.5*

* Mean value of both methods.

smokers and on blood from non-smokers to which carbon monoxide was added are shown in Fig. 1. A significant difference was found between the two methods. In 73 determinations the mean difference was 0.50% COHb, the standard deviation of the difference was 0.77. The correlation coefficient was 0.973. The values for non-smokers are in agreement with previous studies (Goldsmith, 1970; Shield, 1971).

The results of the measurement of COHb at the different stages of gas equilibration in the DCA-1 are shown in Table I.

The mean value of the differences of the COHb concentrations before deoxygenation and after oxygenation was $-0.21 \pm 0.52\%$ COHb. This slight decrease in the COHb concentrations during the run is significant ($p < 0.05$). According to Roughton (1964) a difference in COHb concentration of 1% will shift the P_{O_2} pressure at 50% saturation (i.e. the P50 value) by 0.28 mmHg. This means that the error in the P50 calculations assuming no changes in COHb concentrations during the run will rarely exceed 0.3 mmHg.

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