The Determination of O_2 and CO_2 Content in Blood Containing Halothane

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Arterial and venous blood from dogs was analyzed for O_2 and CO_2 content by the Van Slyke–Neill technique and the Goldstein modification, in the absence and in the presence of 1 per cent halothane in the inspired gases. In addition, O_2 content was calculated from the independent values for hemoglobin, S_{O_2} and P_{O_2}. In the absence of halothane, all three methods provided similar values for O_2 content. In the presence of halothane, O_2 content by the modification agreed with that obtained by calculation but was less, as was CO_2 content, than that obtained by the Van Slyke–Neill technique. Accurate determination of CO_2 and O_2 content in blood containing halothane requires, as with ethyl ether, a modified technique.

THE O_2 AND CO_2 content of blood containing ethyl ether cannot be accurately determined by the Van Slyke–Neill technique,[1-3] but can be found with the modification of Goldstein and associates.[4] We[5] previously demonstrated the validity, but not the necessity, of using the modification for analysis of blood containing halothane. In view of a recent report[6] based on blood O_2 content determinations in the presence of halothane by the Van Slyke technique, it was considered important to determine if a modified technique was, in fact, required for accurate analysis of blood containing halothane.

Materials and Methods

After thiopental (Pentothal) (20 mg/kg) was administered intravenously to four dogs, arterial and venous blood samples were drawn into a syringe containing heparin and mixing beads, both before and an hour after 1 per cent halothane (confirmed by infrared analyzer) was added to the inspired gases (35 per cent O_2 in N_2). After mixing, the samples were analyzed in duplicate by (1) the Van Slyke technique,[1] (2) Goldstein's modification,[4] and (3) a technique involving the use of an Instrumentation Laboratory Co-oximeter (Hb, S_{O_2}) and electrode (P_{O_2}). Oxygen content was calculated from values for Hb, S_{O_2}, and P_{O_2} provided by the last-named technique, with the assumption that 1 gm of oxyhemoglobin combines with 1.34 ml of O_2. Values for CO_2 and O_2 content by the other methods were calculated as suggested for each technique.[1, 4] Hemoglobin values ranged from 8 to 13 gm/100 ml and S_{O_2} values from 100 to 40 per cent.

Results

In the absence of halothane, calculated O_2 content was not different from O_2 content by the Van Slyke technique or the Goldstein modification (table 1). With 1 per cent halothane, the calculated and modification-determined O_2 contents were in agreement, whereas those obtained by the Van Slyke technique were significantly greater. Likewise, in the absence of halothane, significant differences were not present in either O_2 or CO_2 content as determined by the Van Slyke technique or by the modification (table 2). With 1 per cent halothane, however, both O_2 and CO_2 contents were significantly greater with the Van Slyke technique than with the modification. The influence of halothane on values by the Van Slyke technique was evident to similar degrees in both arterial and venous blood.

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TABLE 1. Oxygen Content Differences in the Absence and Presence of Halothane (Mean of Duplicates)

Comparison	O_2 Content Difference, ml/100 ml					
	No halothane			Halothane (1 per cent)		
	No.	Mean	SE	No.	Mean	SE
Van Slyke minus calculated*	8	0.06	0.04	8	0.41†	0.08
Goldstein minus calculated*	8	−0.04	0.07	8	0.02	0.08

* Based on Hb, So_2, and Po_2.
† Significant ($p < 0.05$) by paired t test.

TABLE 2. Individual Blood–Gas Determination Differences by the Van Slyke–Neill Technique and by the Goldstein Modification in the Absence and Presence of Halothane

Measurement	Van Slyke Minus Goldstein, ml/100 ml					
	No Halothane			Halothane (1 per cent)		
	No.	Mean	SE	No.	Mean	SE
O_2 content	16	0.10	0.05	16	0.40*	0.07
CO_2 content	16	0.06	0.14	16	0.33*	0.10
$(A\text{-}V)O_2$	8	−0.09	0.09	8	−0.20	0.16
$(A\text{-}V)CO_2$	8	0.06	0.33	8	−0.06	0.27

* Significant ($p < 0.05$) by paired t test.

Consequently, arteriovenous (A-V) differences in O_2 and CO_2 were not significantly different by the two methods in the presence of halothane.

Comment

In the Van Slyke manometric technique, O_2 and CO_2 in blood are released from chemical combination by the addition of acidified saponin and potassium ferricyanide and extracted by shaking in a partial vacuum. Gas volume is reduced to 2 ml, and total gas pressure is recorded. Changes in pressure at this volume after the addition of sodium hydroxide and, subsequently, sodium hyposulfite, are used to calculate blood CO_2 and O_2, respectively. In this technique, shaking and re-extraction are not carried out between readings because they are time-consuming and unnecessary if the only gases present are O_2, CO_2, N_2, and H_2O vapor. Further, agitation of the mixture after addition of NaOH would result in loss of some of the O_2, along with all of the CO_2, and contribute to erroneously high values for CO_2 and low values for O_2.[4] Because re-extraction is not carried out, any gaseous anesthetic agent initially extracted from the blood sample would re-enter the liquid phase during the subsequent steps and result in falsely high values for both CO_2 and O_2. This, previously observed to occur with ethyl ether,[4] apparently occurred with halothane in the present study.

Goldstein's modification consists essentially of (1) re-extraction before each pressure reading in order to minimize re-entry of anesthetic gases into the liquid phase and (2) empiric determination of the amount of O_2 removed along with CO_2 during shaking and re-extraction after the addition of NaOH. Goldstein *et al.*[4] have demonstrated the necessity of using this modification for analysis of blood containing ethyl ether. The results of the present study extend this requirement to blood containing halothane, particularly if absolute values for single samples rather than A-V differences are required. In the previously mentioned study, wherein Van Slyke analysis was

used on blood containing halothane, the determinations were used only for $(A\text{-}V)O_2$.[6] This was presumably valid, since in the present study the arterial and venous O_2 determinations were equally affected by Van Slyke analysis in the presence of halothane, and $(A\text{-}V)O_2$ was insignificantly affected.

The blood gas analyses of this study were done by Miss Linda L. Richardson and Miss Rebecca D. Machin.

References

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Drugs

HEPARIN Quantitative determinations of heparin in blood at various infusion rates were done during treatment of chronic renal failure by hemodialysis. Blood levels of heparin varied between 5 and 10 μg/ml when a single dose of 50 mg heparin was administered, followed 10 to 20 minutes later by a continuous infusion of 0.3 mg heparin per minute. This applied to patients weighing between 49 and 60 kg. One patient wegihing 82 kg received 0.5 mg heparin/minute. The infusions were maintained for 11 to 15 hours for a total of 210 mg heparin in 12 hours, excluding the 50 mg initial injection. Coagulation time averaged 60 minutes at blood levels of 5 μg heparin/ml blood. At the end of the heparin infusion, the rate of decline of blood levels was independent of the initial heparin concentration. At all concentrations heparin had a half-life of two hours. This was true in all patients, including two who had bilateral nephrectomies. The rate of heparin elimination or inactivation was the same for oliguric or anuric patients and normal individuals, indicating a predominantly extrarenal disposition of heparin. (*Somm, P.: A Study of Continuous Heparinization during Intermittent Hemodialysis, Klin. Wschr. 46: 474 (May) 1968.*)

HYPERTHYROIDISM Imipramine, nortriptyline, chlorpromazine, perphenazine, and chlordiazepoxide were more toxic in hyperthyroid than in healthy mice, while meprobamate and reserpine were not. The increased toxicity was not prevented by pretreatment with phenoxybenzamine or pronethalol. All sedative drugs appeared to have greater depressant effects in hyperthyroid than in normal mice. The margin of safety of phenothiazines, and possibly other drugs, may be reduced in uncontrolled hyperthyroidism in man. (*Ashford, A., and others: Toxicity of Depressant and Antidepressant Drugs in Hyperthyroid Mice, Brit. Med. J. 1: 217, (April) 1968.*)