METABOLIC ACIDOSIS AND HALOTHANE ANAESTHESIA
A Case Report

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Although the effects of anaesthetic agents on the normal ionic balance of the blood have been carefully studied, little attention has been given to the anaesthetic management of the patient whose electrolytic balance has been upset by disease. Derangements of the acid-base balance are rarely encountered in patients selected for elective surgical therapy, but a metabolic acidosis may occur in those suffering from renal failure, uncontrolled diabetes mellitus, or haemorrhagic shock (Moller, 1959).

It is well recognized that ether, cyclopropane, and chloroform cause a transient metabolic acidosis which, in the case of ether, is independent of changes in the Pco₂ (Greene, 1961; Sollmann, 1957; Beecher, Francis and Anfinsen, 1950). It has also been shown that a metabolic acidosis is the immediate response to a respiratory acidosis occurring during conventional anaesthesia in man (Holaday, Ma and Papper, 1957). The respiratory alkalosis caused by hyperventilation may also reduce the normal excess of cations over the non-buffer anions and predispose to a metabolic acidosis (Papadopoulos and Keats, 1959). These acidotic propensities of conventional anaesthetic methods may not be of much consequence in normal circumstances but may be of serious significance when the ionic balance is disturbed by disease.

It has recently been observed that an induced metabolic acidosis is rapidly followed by cardiac arrest in the experimental animal when the preganglionic sympathetic nerves are blocked (Thrower, Darby and Aldinger, 1961). It appears that the acid metabolite (lactic acid) causes cardiovascular failure partly by a direct depression of the ventricular contractile force and partly by reducing the normal sensitivity of the cardiovascular system to noradrenaline (levaterenol). Cardiovascular activity in the acidoic animal is maintained by a compensatory sympathetic activity with a release of catecholamines which is dependent on intact sympathetic nerve pathways. The continuous intravenous infusion of noradrenaline prevents the cardiovascular collapse in the acidoic animal when the sympathetic nerves are blocked. In view of the controversy concerning the depressant effects of halothane on sympathetic activity it was felt that a report on the case history of a severely acidoic patient anaesthetized with halothane might be of interest because of its remarkable similarity to the experimental observations of Thrower and his associates.

CASE REPORT

Male, 71 years. Anuria of 12 days duration. Gradually progressive oliguria for the previous 2 weeks. Prostatectomy performed 3 months previously. Hypertensive heart disease present with electrocardiographic evidence of an old septal infarct; sinus rhythm at 84 beats a minute. Blood pressure 180/100 mm Hg; known to have been 230/130 mm Hg before admission. Conscious, rational, drowsy, and dry. Purpuric spots on arms and conjunctivae. Moderate oedema of dependent parts. Breathing increased. No gross pathological changes detected in the lungs.

Blood chemistry: Blood urea 392 mg per cent.
Serum sodium 137 m-equiv/l.
Serum potassium 6 m-equiv/l.
Serum chloride 89 m-equiv/l.
Plasma bicarbonate 16 m-equiv/l.

Operation. Urgent cystoscopy, retrograde catheterization of the ureters and probable nephrostomy.

Premedication. No drugs administered.

Anaesthesia. A Cotel-Keating pulse monitor (Keating, 1952) was attached to the right thumb and the pulse wave monitored throughout the operation.*

*The authors consider that the pulse wave, as depicted on the meter, is closely related to the volume changes associated with vascular pulsations in the digit, and that it should therefore be regarded as a plethysmograph or "plethysmometer".
Details of the changes in the pulse wave, pulse rate, and systolic blood pressure are presented in figure 1.

Anaesthesia was induced with 6 per cent halothane in an oxygen flow of 5 l./min into a Waters system without the canister. A cuffed endotracheal tube was inserted after 3 minutes and anaesthesia maintained with 50 ml of halothane vapour in 1 litre of oxygen a minute (i.e. the vaporizer was set at 5 per cent) into a closed circuit with carbon dioxide absorption.

![HALOTHANE VAPOUR (ml/min)](image1)

HALOTHANE VAPOUR (ml/min)

300

50

NORADRENALINE (µg/min)

PULSE WAVE

SYSTOLIC B.P.

PULSE

500 ml

DEXTROSE 5 per cent

100

50

300

100

50

0

Changes in the pulse rate, systolic pressure, and peripheral pulse wave during the administration of halothane and noradrenaline to a acidic (metabolic) patient.

Brisk spontaneous respiration persisted, the pulse rate dropped to 72 beats a minute, the systolic pressure (measured by inflating a brachial cuff until the pulsation in the pulse meter stopped) fell to 110 mm Hg, and the amplitude of the peripheral pulse wave increased to 25 mm. Ten minutes later the halothane was discontinued as the blood pressure had dropped to 70 mm Hg and the amplitude of the pulse wave remained at 3 mm. Cyanosis or pallor did not appear, the blood remaining apparently well oxygenated. Half a litre of 5 per cent dextrose in water was rapidly injected intravenously (3 minutes) and failed to cause any change in the blood pressure or pulse wave.

Retrograde catheterization of the ureters was impossible and the surgeon requested permission to perform a nephrostomy. As the systolic blood pressure was still in the region of 40 mm Hg and the peripheral pulse wave barely perceptible, an intravenous infusion of noradrenaline 4 mg in half a litre of 5 per cent dextrose in water was started at 60 drops a minute (15 drops = 1 ml). Within 3 minutes the systolic pressure increased to 140 mm Hg and the amplitude of the pulse wave rose to 30 mm. Halothane vapour at a rate of 50 ml/min was then fed into the circuit as the patient was inadequately relaxed for surgery.

The noradrenaline drip rate was reduced to 20 drops a minute as the blood pressure continued to rise slowly. These doses of halothane and noradrenaline were continued for the next 35 minutes whilst a nephrostomy was successfully completed, the blood pressure remaining steady at 120 mm Hg systolic. The pulse rate was perfectly regular at 70 beats a minute and the amplitude of the pulse wave remained at 30 mm. The administration of halothane was stopped as the skin sutures were being inserted and the endotracheal tube removed. The noradrenaline infusion was discontinued 10 minutes later as the blood pressure was approaching pre-anaesthetic levels. The patient was fully conscious some 20 minutes later with a blood pressure of 170/100 mm Hg.

A small amount of urine (240 ml) was excreted via the nephrostomy during the next 12 hours, after which no further urine was passed. Haemodialyses produced temporary improvements until the patient died suddenly on the tenth postoperative day from what appeared to be an acute coronary occlusion. Necropsy revealed an acute myocardial infarction, coronary atherosclerosis, and severe pyelonephritis.

DISCUSSION

Halothane was administered to this patient for the following three reasons specifically related to the renal pathology and its concomitant electrolytic disturbance.

Unlike ether, cyclopropane, and nitrous oxide, it does not cause a metabolic acidosis even when a respiratory acidosis is allowed to occur during anaesthesia (Holmdahl and Payne, 1960; Dobkin, Harland, and Fedoruk, 1961).

Recent investigations have indicated that halothane reverses the renal shut-down associated with severe trauma (Smith, Fabian and Carnes, 1961) and may therefore be regarded as being without the antiuretic action of other anaesthetic agents (Aprahamian et al., 1959; Kovacs et al., 1958).

In the experience of one of us (M.J.) halothane has provided smooth and uneventful anaesthesia for three cases with similar but less severe pathological changes. In the only other case of equal severity encountered by us (Johnstone, 1955) the use of nitrous oxide and oxygen with relaxant anaesthesia provoked a ventricular flutter-fibrillation which persisted for 4 hours before it was reversed by the glucose-insulin therapy.
The initial hypotensive response to halothane during the induction of anaesthesia was associated with a transient increase in the amplitude of the peripheral pulse wave and may therefore be attributed to peripheral vasodilatation. As the depth of anaesthesia increased the hypotension became profound, the pulse rate remained unchanged, and the amplitude of the pulse wave dropped to barely perceptible dimensions. In view of the rapid collapse of the pulse wave it would seem that this phase of the hypotensive crisis was due to weakening of the ventricular contractile force as the result of the combined effects of acid metabolites, advanced myocardial disease with coronary sclerosis, and halothane anaesthesia.

It is not improbable that the acidosis was the major aetiological factor in the collapse. Extensive experience in vasculometry during halothane anaesthesia has revealed the following points: larger doses of halothane fail to cause such a sudden and persistent decrease in the pulse wave, even in patients with advanced myocardial disease; the withdrawal of the halothane has been followed by immediate increases in the systolic blood pressure and in the amplitude of the pulse wave; the rapid intravenous infusion of dextrose solutions has invariably caused immediate increases in the systolic pressure and in the amplitude of the pulse waves. The complete absence of any sign of cardiovascular improvement in this case for 15 minutes after withdrawing the halothane, despite the intravenous injection of half a litre of dextrose solution, was probably due to the lack of excretion of the halothane because of the profound circulatory depression.

Noradrenaline was chosen to reverse the hypotension because of its equal potency to adrenaline in augmenting the myocardial contractile force (Goldberg, et al., 1960) and its lesser tendency to cause ectopic rhythms during halothane anaesthesia (Hall and Norris, 1958). Methoxamine, although effective in patients with normal electrolyte balance, was presumably contra-indicated as it is devoid of a direct stimulant action on the myocardium (Goldberg, et al., 1960).

The cardiovascular response to noradrenaline was immediate and complete and persisted despite the re-introduction of a relatively high dose of halothane. The considerable and sustained increase in the amplitude of the peripheral pulse wave suggests that the circulatory improvement was effected by an increased myocardial contractility and was unrelated to peripheral vasoconstriction. It may be argued that the noradrenaline expedited the venous return by constriction of the venous channels, but this seems unlikely, as the calibre of the superficial veins appeared unaltered.

It is obvious that halothane did not depress to any significant degree the sensitivity of the diseased myocardium depressed by acidosis to exogenous noradrenaline, but it may well have blocked the production of the endogenous noradrenaline necessary for the maintenance of myocardial efficiency in these circumstances. The circulatory collapse which followed the administration of halothane is remarkably similar to the fatal collapses described by Thrower, Derby and Aldinger (1961) in dogs following the infusion of lactic acid in the presence of sympathetic blockade. The satisfactory reaction to the simultaneous administration of halothane and noradrenaline would seem to provide support for the theory that halothane exerts its hypotensive effect by blocking sympathetic activity at some point proximal to the sympathetic nerve endings.

**SUMMARY**

Halothane anaesthesia caused a profound and persistent circulatory collapse in an elderly patient with severe metabolic acidosis due to renal disease. The collapse was immediately reversed by the intravenous infusion of noradrenaline which permitted a nephrostomy to be performed under halothane anaesthesia. In view of the known hypersensitivity of acidotic animals to the cardiovascular effects of sympathetic blockade, it is suggested that noradrenaline infusions may be required to maintain cardiovascular function during halothane anaesthesia in patients with metabolic acidosis.

**ACKNOWLEDGMENTS**

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**REFERENCES**


**CORRESPONDENCE**

**ANAESTHESIA FOR CAESAREAN SECTION**

Sir,—I was interested to read the paper by Dr. C. A. G. Armstrong on “A Method of Anaesthesia for Caesarean Section” (Brit. J. Anaesth. (1961), 33, 408). During the evolution of his present technique, one of the chief aims has been to reduce the incidence of vomiting or regurgitation of stomach contents by the mother. May I suggest one further modification which may help in this respect? Before induction of anaesthesia the patient should be allowed to breathe 100 per cent oxygen for some 3 minutes. This will obviate the need for manual inflation of the lungs during the period between induction and intubation of the trachea. Inflation of the lungs via a facepiece in the presence of a full stomach is one of the causes of reflux emptying of stomach and oesophagus (Wylie and Churchill-Davidson, 1960).

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**REFERENCE**