THE EFFECT OF FLUOTHANE ON ACID-BASE BALANCE

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FLUOTHANE is a recent addition to the anesthetic agents presently available, but already many reports indicate that it should be employed with precision.[1-5] Because of its great potency, and its nonexplosive and nonflammable properties,[6, 7] the efficacy of employing this agent in a nonrebreathing system with controlled artificial respiration was studied to determine its value in major operations for which cyclopropane or ether might otherwise be desired. This report deals particularly with a study of the effect on acid-base homeostasis.

MATERIALS AND METHODS

Data were collected on 90 patients. Each was given premedication of a small dose of a phenothiazine derivative (45 patients) or meperidine (43 patients), together with atropine (45 patients) or scopolamine (45 patients). Anaesthesia was induced with a sleep dose of thiopental (27 patients) or thiamylal (63 patients) following sufficient Gallamine (63 patients), dimethyl *d*-tubocurarine (22 patients) or *d*-tubocurarine (5 patients) to accomplish endotracheal intubation. Anaesthesia was then maintained in a nonrebreathing system with nitrous oxide, oxygen (2:1) and Fluothane, which was delivered through a calibrated Fluotec vaporizer. Small doses of muscle relaxants were given subsequently as required.

For each patient, ventilation was regulated mechanically with a predetermined tidal volume (fixed), pressure amplitude (variable) and rate of respiration (fixed) by means of an Etsten hand ventilator connected to the endotracheal tube with nondistensible tubing through a series of nonreturn valves. The ventilator was driven automatically by a double-action piston motor * which was actuated by compressed air. The ventilation parameters which were applied in each case were computed from the Radford nomogram and were corrected according to factors related to the patient's age, body build, the posture adopted and the presence of emphysema or cardiac incompetence.[8, 9] Once a stable depth of surgical anaesthesia was achieved, the pressure gauge was checked at intervals to determine whether there was any alteration in respiratory resistance which might indicate a change in compliance of the lungs.

During the period of anaesthesia, dextrose, 5 per cent in water, or whole blood transfusions were administered, as necessary. No base was administered to any of these patients during the anaesthetic period or before the last blood sample was taken. Hypothermia and hypotension were not induced intentionally in any of these patients.

Acid-base changes were determined by drawing arterial blood samples anaerobically from the brachial artery immediately before induction, after a stable surgical plane was established for 20 to 30 minutes, and every 30 minutes during maintenance of anaesthesia. Additional samples were drawn immediately after the patient's trachea was extubated at the end of the operation, and again 30 minutes later in the recovery room. The arterial blood samples were analyzed immediately for *p*H, total CO_2, haematocrit value and oxygen saturation by standard laboratory techniques as described in a previous report.[8] Plasma CO_2, pCO_2, plasma bicarbonate and fixed acid changes were calculated from the above data. The *p*H and plasma bicarbonate were plotted on a graph to obtain a visual indication of alterations in fixed acids.

Complete blood analyses were carried out in 30 patients. These patients were divided into two groups according to their age—15 patients were between 25 and 50 years (mean 40) and 15 patients were between 50 and 80 years (mean 67). Only serial *p*H determinations were made in the other 60 patients. The preoperative data were compared with results of studies in eight normal subjects who had

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* Supplied by Ohio Chemical & Surgical Company, Madison, Wisconsin.

TABLE 1

EFFECT OF FLUOTHANE ANAESTHESIA ON DATA FROM SERIAL ARTERIAL BLOOD *p*H, PER CENT OXYGEN SATURATION, CARBON DIOXIDE TENSION AND PLASMA BICARBONATE IN MILLIMOLES PER LITER (15 PATIENTS, AGES 25 TO 50 YEARS)

Patient	Age	Build	Posture	Op. Site	Anaesth. Time (min.)	Before Anaesthesia				Steady Anaesthesia				During Maintenance				End of Anaesthesia				30 Minutes After Anaesthesia			
						pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)
D. P.	27	L	S	↑ABD	90	7.32	91	39	20.9	7.39	97	36	20.9	7.38	97	37	21.1	7.26	96	54	23.0	7.28	94	50	22.9
G. B.	29	M	T 15	↓ABD	105	7.36	98	36	20.0	7.42	100	26	16.6	7.44	100	25	16.3	7.37	95	31	17.5	7.33	99	38	19.2
L. C.	34	M	T 15	↓ABD	195	7.37	100	31	15.4	7.46	98	23	13.5	7.47	98	24	16.4(4)	7.39	98	32	17.3	7.30	95	40	18.0
E. A.	35	O	S	↑ABD	145	7.34	95	38	19.9	7.42	99	26	16.2	7.43	97	25	16.0(2)	7.31	100	32	15.7	7.22	100	45	17.8
D. R.	36	L	Lat	↑ABD	76	7.25	74	53	22.4	7.27	100	48	21.7	7.27	100	48	21.7	7.08	97	53	16.2	7.22	90	57	22.7
L. K.	36	M	T 15	↓ABD	115	7.23	89	63	25.8	7.39	97	28	16.6	7.59	97	22	20.7	7.54	97	26	21.7	7.35	89	32	17.2
F. C.	37	O	S	↑ABD	130	7.36	95	47	25.6	7.41	99	39	25.3	7.39	98	43	25.0	7.35	99	43	22.9	7.38	98	41	23.3
Z. D.	41	M	JK	Spine	185	7.30	83	35	16.9	7.40	99	34	20.5	7.38	98	34	19.6(5)	7.36	99	39	21.4	7.33	99	41	20.9
J. Z.	42	O	T 10	↓ABD	75	7.33	80	41	21.0	7.47	97	25	18.0	7.48	99	26	18.9	7.38	100	36	19.0	7.29	100	42	19.4
L. H.	43	O	T Lith	↓ABD	85	7.34	98	39	19.1	7.43	100	28	16.9	7.44	100	28	17.1	7.42	100	30	17.3	7.42	100	33	18.8
M. B.	46	O	T 10	↓ABD	155	7.34	74	34	18.0	7.41	99	27	16.9	7.39	100	27	15.6	7.38	100	29	16.4	7.35	98	33	17.5(2)
G. J.	47	M	S	↑ABD	135	7.34	93	43	22.6	7.44	98	33	21.4	7.41	99	31	19.1(2)	7.38	100	35	20.0	7.32	97	42	21.0
G. Z.	48	M	S	↑ABD	175	7.27	94	55	24.5	7.38	93	36	20.8	7.36	94	37	20.3	7.34	94	41	20.6	7.25	91	48	20.4
A. D.	49	L	S	↑ABD	210	7.31	97	49	23.3	7.39	78	36	20.0	7.44	100	25	16.4(3)	7.37	100	32	17.7	7.34	100	38	20.0
M. C.	49	O	T Lith	↓ABD	100	7.35	95	38	19.4	7.45	100	25	16.3	7.45	100	27	17.9	7.42	100	28	16.4	7.37	100	37	20.1
Mean	40				131	7.32	90	43	21.0	7.40	97	31	18.8	7.42	98	31	18.8	7.36	98	36	18.9	7.32	97	41	19.9
S. D. ± 7					45	0.04	8	9	3.0	0.05	5.5	7	3.0	0.07	2	8	2.6	0.10	2	8	2.5	0.06	4	7	2.0

TABLE 2

EFFECT OF FLUOTHANE ANAESTHESIA ON DATA FROM SERIAL ARTERIAL BLOOD *p*H, PER CENT OXYGEN SATURATION, CARBON DIOXIDE TENSION AND PLASMA BICARBONATE IN MILLIMOLES PER LITER (15 PATIENTS, AGES 50 TO 80 YEARS)

Patient	Age	Build	Posture	Op. Site	Anaesth. Time (min.)	Before Anaesthesia				Steady Anaesthesia				During Maintenance				End of Anaesthesia				30 Minutes After Anaesthesia			
						pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)	pH	O_2 Sat. (%)	pCO_2 (mm. Hg)	HCO_3^- (mM/L)
N. H.	51	O	T 10	↓ABD	140	7.35	98	39	20.7	7.40	100	33	19.0	7.44	100	27	17.7 (2)	7.41	100	30	18.4	7.36	98	36	19.6
J. G.	52	M	T Lith	↓ABD	95	7.34	96	46	24.0	7.35	100	42	22.7	7.36	98	41	22.4	7.34	81	44	23.3	7.33	93	45	23.0
S. P.	60	O	S	↓ABD	145	7.35	95	44	23.3	7.37	100	35	20.0	7.39	95	35	20.6	7.34	95	40	20.9	7.33	92	41	21.0
E. H.	63	M	S	↑ABD	110	7.31	83	49	23.8	7.42	100	32	19.0	7.41	95	30	17.5 (2)	7.35	100	37	19.0	7.28	97	46	20.5
G. S.	63	M	S	↑ABD	120	7.33	93	50	25.4	7.46	98	35	19.5	7.45	100	28	19.0	7.38	100	34	19.2	7.39	100	34	19.4
T. S.	66	O	S	↑ABD	295	7.35	95	42	21.9	7.49	100	27	19.0	7.45	100	29	19.2 (5)	7.38	100	39	20.6	7.33	100	44	21.3
C. H.	68	L	S	↑ABD	75	7.30	92	44	21.0	7.46	100	25	17.3	7.45	97	28	19.2	7.28	99	45	20.4	7.37	96	32	17.7
H. N.	68	O	S	↑ABD	115	7.34	95	43	22.7	7.44	97	33	21.6	7.38	100	34	19.3	7.37	100	36	20.2	7.29	93	51	23.6 (2)
H. L.	69	M	S	↑ABD	240	7.24	90	50	20.9	7.33	92	36	18.4	7.36	94	35	18.2 (5)	7.35	95	32	17.1	7.20	95	57	21.9
J. E.	69	O	S	↓ABD	105	7.31	74	47	22.8	7.42	95	26	16.7	7.46	95	27	19.0	7.41	100	35	20.0	7.36	100	41	22.2
J. T.	71	O	S	↓ABD	150	7.28	90	43	19.7	7.33	100	33	16.9	7.34	100	34	17.7 (2)	7.34	100	32	17.0	7.29	94	39	18.0
M. R.	72	M	T Lith	↓ABD	80	7.33	97	41	21.1	7.46	100	16	11.3	7.50	100	13	10.8	7.46	100	28	19.6	7.38	98	38	21.0
M. B.	75	O	S	↑ABD	100	7.40	86	41	24.6	7.53	92	23	18.7	7.51	93	21	16.2	7.35	96	40	21.4	7.39	88	38	22.3
E. C.	76	O	S	↑ABD	185	7.39	90	44	26.1	7.37	96	41	23.0	7.43	92	35	22.1 (2)	7.40	98	33	20.1	7.30	99	45	21.9
F. T.	76	M	S	↑ABD	190	7.30	100	41	20.1	7.36	100	41	22.8	7.51	98	26	19.8 (3)	7.38	95	35	20.2	7.37	96	34	19.4
Mean	67				143	7.33	92	44	22.5	7.41	98	32	19.1	7.43	97	29	18.6	7.37	97	36	19.8	7.33	96	41	20.8
S. D. ±	8				62	0.04	7	3	2.0	0.06	3	7	3.0	0.06	3	7	2.7	0.04	5	5	1.6	0.05	3	7	1.7

TABLE 3

EFFECT OF FLUOTHANE ANAESTHESIA ON DATA FROM SERIAL ARTERIAL BLOOD *p*H
(60 PATIENTS, AGES 15–80 YEARS)

Patient	Age	Build*	Position†	Operative Site	Anaesthesia Time	Before Anaesthesia (Premedicated)	Steady Anaesthesia	During Maintenance	End of Anaesthesia	30 Min. After Anaesthesia
					minutes	pH				
L. A.	71	M	S	↓ABD	155	7.32	7.37	7.36	7.34	7.31
G. B.	64	M	S	↓ABD	155	7.34	7.42	7.44	7.40	7.36
M. B.	56	L	S	↑ABD	200	7.32	7.41	7.38	7.33	7.29
J. B.	78	O	T Lith	↓ABD	175	7.30	7.36	7.37	7.33	7.32
N. B.	41	O	S	↑ABD	110	7.40	7.43	7.48	7.42	7.43
G. C.	45	M	S	↑ABD	110	7.32	7.42	7.42	7.26	7.29
E. C.	57	M	S	↑ABD	125	7.36	7.44	7.55	7.53	7.34
Y. C.	21	L	Prone	Spine	370	7.36	7.42	7.45(8)	7.43	7.38
M. C.	69	M	S	↑ABD	90	7.33	7.43	7.47	7.42	7.37
V. D.	54	M	T Lith	↓ABD	195	7.39	7.44	7.41	7.42	7.34
V. E.	50	M	S	↓ABD	80	7.40	7.46	7.43	7.35	7.36
A. F.	45	M	S	↑ABD	130	7.34	7.49	7.49	7.31	7.35
N. F.	22	M	Prone	Spine	330	7.40	7.46	7.45(5)	7.47	7.38
R. G.	25	M	S	↑ABD	70	7.35	7.47	7.47	7.33	7.36
C. G.	56	M	S	↑ABD	90	7.28	7.44	7.39	7.31	7.33
C. H.	63	O	S	↑ABD	205	7.34	7.47	7.45(4)	7.38	7.35
I. H.	75	O	S	↑ABD	70	7.36	7.46	7.49	7.45	7.29
M. H.	36	M	T Lith	↓ABD	80	7.31	7.43	7.43	7.39	7.34
L. H.	28	L	S	↑ABD	140	7.33	7.45	7.45(3)	7.33	7.34
G. I.	44	O	S	↑ABD	80	7.34	7.38	7.37	7.28	7.32
J. J.	48	O	Prone	Spine	330	7.30	7.34	7.36(6)	7.29	7.30
A. K.	29	M	T 15	↓ABD	125	7.32	7.47	7.52	7.46	7.30
S. L.	15	L	Prone	Spine	300	7.40	7.51	7.47(5)	7.33	7.37
L. L.	58	M	S	↑ABD	145	7.37	7.50	7.52	7.48	7.40
A. L.	57	M	S	Neck	65	7.35	7.44	7.44	7.38	7.33
G. L.	36	M	S	↑ABD	165	7.33	7.42	7.40(4)	7.37	7.38
C. L.	74	O	S	↑ABD	240	7.34	7.42	7.40(5)	7.34	7.31
A. M.	56	M	S	Neck	115	7.31	7.35	7.38(2)	7.39	7.27
J. M.	44	M	S	↓ABD	70	7.31	7.38	7.38	7.37	7.34
M. M.	57	M	S	↑ABD	120	7.32	7.39	7.43	7.42	7.36
D. M.	53	M	T 15	↓ABD	130	7.35	7.40	7.41	7.36	7.37
R. N.	25	M	S	↓ABD	145	7.37	7.46	7.49(2)	7.41	7.33
A. N.	31	L	Prone	Spine	280	7.33	7.45	7.43(4)	7.30	7.32
S. B.	70	M	S	↑ABD	135	7.30	7.42	7.39	7.40	7.33
E. H.	42	O	S	↑ABD	115	7.31	7.39	7.38	7.36	7.32
A. R.	60	O	S	↓ABD	90	7.38	7.47	7.45	7.42	7.40
B. H.	54	O	S	↓ABD	190	7.34	7.42	7.43(3)	7.37	7.31
M. B.	59	O	T 15	↓ABD	120	7.33	7.41	7.40	7.37	7.32
R. B.	58	M	S	↓ABD	95	7.36	7.44	7.45	7.38	7.37
M. N.	55	M	S	↓ABD	195	7.32	7.39	7.36(4)	7.26	7.30
N. N.	74	M	S	↓ABD	90	7.28	7.37	7.39	7.32	7.30
V. P.	41	O	S	↑ABD	65	7.30	7.40	7.40	7.37	7.32
A. P.	32	L	T Lith	↓ABD	140	7.35	7.51	7.53	7.34	7.36
A. P.	69	L	S	↓ABD	75	7.31	7.42	7.40	7.30	7.27
C. R.	65	M	Prone	Spine	300	7.33	7.38	7.34(5)	7.32	7.28

* L—Lean, M—Medium, O—Obese. These are related to age, height, and weight tables from the Life Extension Institute of New York City.

† S—Supine horizontal; T 15—Trendelenberg 15 degrees; Lat—Lateral flexed; T Lith—Lithotomy and head low; JK—Prone jackknife.

Figures in parentheses indicate averaged data from number of samples noted.

TABLE 3—*Continued*

Patient	Age	Build*	Position†	Operative Site	Anaesthesia Time	Before Anaesthesia (Premedicated)	Steady Anaesthesia	During Maintenance	End of Anaesthesia	30 Min. After Anaesthesia
					minutes	pH				
U. R.	45	M	T 10	↓ABD	90	7.39	7.40	7.44	7.43	7.39
F. S.	63	O	L	↓ABD	185	7.32	7.40	7.41 (2)	7.33	7.32
L. S.	45	O	T Lith	↓ABD	105	7.38	7.35	7.38	7.37	7.28
A. S.	74	M	S	↓ABD	155	7.27	7.35	7.37 (2)	7.32	7.29
T. S.	41	O	T 15	↓ABD	115	7.35	7.51	7.53	7.48	7.31
F. S.	77	O	S	↑ABD	125	7.33	7.40	7.39 (2)	7.30	7.31
F. S.	36	M	S	↑ABD	160	7.33	7.40	7.43 (3)	7.37	7.35
F. T.	39	O	T Lith	↓ABD	115	7.39	7.45	7.44	7.37	7.41
M. T.	79	O	S	↑ABD	220	7.36	7.42	7.43 (5)	7.37	7.38
R. T.	47	M	T 15	↓ABD	75	7.42	7.50	7.46	7.46	7.45
H. T.	75	M	S	↑ABD	115	7.34	7.39	7.44 (2)	7.27	7.30
H. V.	50	M	Prone	Spine	120	7.34	7.43	7.43	7.41	7.39
P. W.	59	O	S	↑ABD	305	7.28	7.38	7.32 (9)	7.27	7.29
W. W.	41	L	S	↑ABD	485	7.34	7.38	7.41 (12)	7.34	7.31
K. W.	42	O	T 15	↓ABD	170	7.36	7.47	7.44 (2)	7.45	7.32
Mean	51				160	7.34	7.42	7.43	7.37	7.34
S. D.	17					0.03	0.04	0.05	0.06	0.04

not received premedication and from whom two separate arterial blood samples were analyzed, each in duplicate, to determine "normal values" observed in our laboratory.[8] The variation (standard deviation of the mean) observed in the arterial blood data was analyzed statistically and the Fisher *t* test was applied to determine whether alterations in the serial analyses from each patient could be due to chance alone.

Results

The data obtained from the arterial blood analyses appear in tables 1, 2 and 3. There was a highly significant difference between the preinduction level of *p*H, plasma bicarbonate, pCO_2 and oxygen saturation and those observed during stable anaesthesia ($p < .001$). The *p*H, plasma bicarbonate and pCO_2 values during maintenance of anaesthesia were also very significantly different from those estimated 30 minutes after the end of the operation ($p < .001$). The *p*H and pCO_2 levels immediately after extubation also differed significantly from those determined during stable anaesthesia ($p < .01$).

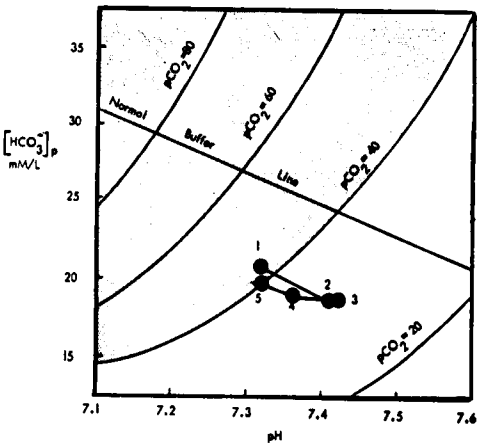

FIG. 1. Represents the mean plasma bicarbonate, *p*H and pCO_2 in the arterial blood in 15 patients ages 27–50 (mean 40) during Fluothane anaesthesia delivered through a Fluotec vaporizer with nitrous oxide and oxygen (2 : 1) in a nonrebreathing system and controlled artificial ventilation. The numbered points indicate: (1) before induction; (2) after a stable surgical plane of anaesthesia was in progress for 30 minutes; (3) mean values from data obtained at 30 minute intervals during maintenance; (4) immediately after extubation and breathing spontaneously; (5) 30 minutes after anaesthesia.

In the majority of the patients there was some depression of the oxygen saturation before anaesthesia, probably as a result of premedication. After induction and during maintenance of anaesthesia, full oxygen saturation was usually evident. Oxygen was administered in the recovery room in the elderly and the poor-risk patients in order to assure this.

In every case there was a rise in the *p*H (approximately 0.1) after induction of anaesthesia, and this was maintained until administration of the anaesthetic was terminated, at which time it rapidly returned to the preoperative level. Figures 1 and 2 show that the mean changes in *p*H and plasma bicarbonate were in a direction which was essentially parallel to the normal buffer line. This indicates that pCO_2 alterations were not affected by a metabolic component. There was a trend toward metabolic acidosis in only one patient in this study. However, acid-base balance returned to normal at termination of the anaesthetic procedure (figs. 3 and 4).

Smooth anaesthesia was easy to maintain with concentrations of Fluothane which are stated to produce a light level of anaesthesia (< 0.5 per cent Fluothane) even with the most stimulating types of surgical procedures (diaphragmatic hernia repairs, spinal fusion and gastrectomy). In none of the 90 patients in this study was it necessary to exceed 0.5 per cent Fluothane with nitrous oxide, 65 per cent. Following induction of anaesthesia it was also observed generally that it was unnecessary to administer bronchodilator drugs, even to those patients with severe emphysema, because the lungs were very easy to inflate after the Fluothane was added. This was reflected on the pressure gauge of the respirator, which usually showed a reduced inflation pressure after it was adjusted initially to 15 mm. of mercury.

The patients in this study recovered from anaesthesia rapidly and without excessive salivation or vomiting.

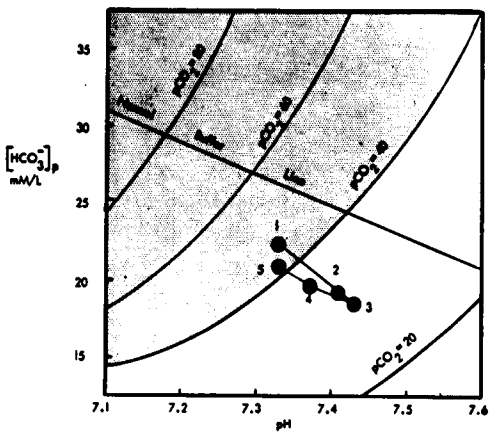

FIG. 2. Represents the mean plasma bicarbonate, *p*H and pCO_2 in the arterial blood in 15 patients ages 50–80 (mean 67) during Fluothane anaesthesia delivered through a Fluotec vaporizer with nitrous oxide and oxygen (2 : 1) in a non-rebreathing system and controlled artificial ventilation. The numbered points indicate: (1) before induction; (2) after a stable surgical plane of anaesthesia was in progress for 30 minutes; (3) mean values from data obtained at 30 minute intervals during maintenance; (4) immediately after extubation and breathing spontaneously; (5) 30 minutes after anaesthesia.

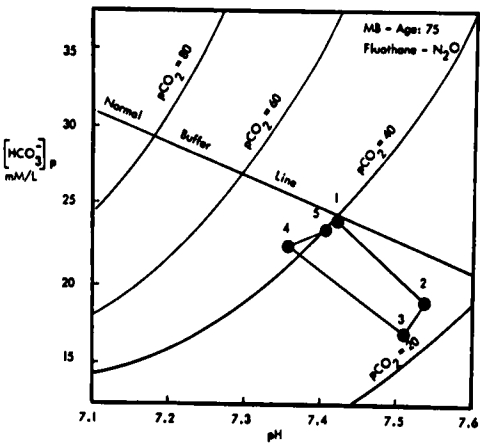

FIG. 3. Represents plasma bicarbonate, *p*H and pCO_2 of an acutely ill 75 year old jaundiced woman. Observe slight fall in plasma bicarbonate during maintenance of anaesthesia in a direction which is perpendicular to the normal buffer line, which indicates a trend toward metabolic acidosis. However, this trend disappeared at the end of anaesthesia, and the preanaesthetic state of homeostasis returned spontaneously.

DISCUSSION

In healthy dogs anaesthetized with Fluothane-air [6, 10] in a non-rebreathing system during spontaneous breathing, Fluothane caused depression of the tidal volume which was proportional to the depth of anaesthesia, with a lesser depression of the respiratory rate. These changes were accompanied by profound al-

Patient MB Hosp.# 2701 Age 75 Sex F Ht. 60" Wt. 139# BSA 1.60 Physical State 4

Anaesth.# 1076 Premed.: Atropine 0.4mg Anaesthetics: Thiamylal 350mg. Gallamine 100mg. Fluothane - Nitrous oxide Build: Obese

Pulm. Vent.: Method- ETSTEN Mech. NR Amplitude: +15,-2,0 3 phases

Blood Pressure: Preop.: 160/130 During Anaesth.: 110 - 160/ 90 - 124 Postop.: Steady

Ventilation Data	Control				
Time	7.30	8.15	8.45	9.10	9.35
Tidal Volume	SR	550	550	SR	SR
Rate	22	18	18	24	22
Minute Volume		9.9 L	9.9 L		
Arterial Blood Data	Room air /--------General Anaesthesia----------/				Room air
Hgb.	15.0				14.7
Hct.	51	52	51	50	51
pH	7.40	7.53	7.51	7.35	7.39
Total CO_2 content mM/L	20.9	15.5	13.6	18.8	19.2
Plasma CO_2 content mM/L	25.8	19.4	16.8	22.6	23.4
Plasma HCO_3^- mM/L	24.6	18.7	16.2	21.4	22.3
pCO_2 mm.Hg.	41	23	21	40	38
pO_2 mm.Hg.		74	79	100	70
% O_2 saturation	86	92	93	96	88

Summary & Remarks: Cholecystectomy & CBD Exploration. Supine - horizontal position. Anaesthesia was maintained for 95 minutes with a non rebreathing system and fluotec vaporizer. Brief period of hypotension after induction corrected with Cedilanid. Although patient had recent history of myocardial infarction, congestive heart failure and has marked hypertension (205/130), and auricular fibrillation - she had an uneventful postanaesthetic course.

FIG. 4. Protocol of respiratory data from same patient as in figure 3.

terations in acid-base balance that were indicative of asphyxia. When the depth of anaesthesia was increased, progressive respiratory failure developed. Prompt resuscitation after respiratory arrest restored the dogs to normal, otherwise the heart eventually stopped in diastole. A study by Devine, Hamilton and Pittinger [11] was carried out on 7 patients with normal cardio-respiratory systems and metabolism. Fluothane was administered with nitrous oxide-oxygen (7:3) from a Copper Kettle to produce light (0.4 per cent inspired), moderate (0.8 per cent inspired and deep (1.5 per cent inspired) anaesthesia. Progressive CO_2 retention resulted, accompanied by a corresponding decrease in alveolar ventilation and a significant reduction in the response to stimulation with 5 per cent carbon dioxide. These studies indicate that the respiratory depression due to Fluothane or Fluothane-nitrous oxide anaesthesia is similar to that which is seen with corresponding concentrations of cyclopropane. [I believe, however, that Fluothane anaesthesia should not be administered for major surgical procedures unless the anaesthetist is prepared to assist or control the breathing of the patient.]

In recent reports [8, 9] of acid-base balance during general anaesthesia for major surgical procedures, it was found that when adequate pulmonary ventilation was provided it was usually possible to maintain acid-base homeostasis without difficulty, with all the commonly employed anaesthetic agents. This statement may be expanded now to include Fluothane-nitrous oxide anaesthesia if it is used in a non-rebreathing system with an accurately calibrated vaporizer.

Other reports vary regarding the effect on breathing.[1, 4, 12] However, in these reports, the exact vapor concentration was unknown (uncalibrated vaporizer), assistance of respiration may have been applied improperly (pressure and volume unknown), or the anesthetic system may have had a carbon dioxide "leak" (nonrebreathing system not used). The lack of the third factor emphasizes the point that study of the respiratory effects of anaesthetics must exclude anaesthetic circuits in which carbon dioxide absorption may be inefficient.[18]

SUMMARY

Fluothane was administered to 90 patients undergoing major operations with a calibrated vaporizer together with nitrous oxide and oxygen (2:1) in a nonrebreathing system. Artificial respiration was provided with a ventilator with a fixed volume control and variable regulated pressures. The ventilator was set to the requirements of the individual patient according to previously procured data which took into account the size, age, posture and condition of the patient's cardiorespiratory system. Data derived from arterial blood samples showed that there was no evidence of fixed acid accumulation even during prolonged anaesthesia and that oxygen saturation was within normal limits throughout the anaesthetic. The maintenance of a stable level of surgical anaesthesia was accomplished in this system with a relatively small amount of Fluothane.

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REFERENCES

1. Hudon, F., Jacques, A., Clavet, M., and Houde, J.: Clinical Observations on Fluothane Anaesthesia, Canad. Anaesth. Soc. J. 4: 221 (July) 1957.
2. Chang, J., Macartney, H. H., and Graves, H. B.: Clinical Experience with Fluothane, New Non-Explosive Agent, Canad. Anaesth. Soc. J. 4: 187 (July) 1957.
3. MacKay, I. M.: Clinical Evaluation of Fluothane with Special Reference to Controlled Percentage Vaporizer, Canad. Anaesth. Soc. J. 4: 235 (July) 1957.
4. Brennan, H. J., Hunter, A. R., and Johnstone, M.: Halothane; Clinical Assessment, Lancet 2: 453 (Sept. 7) 1957.
5. Stephen, C. R., Lawrence, J. H., Fabian, L. W., Bourgeois-Gavardin, M., Dent, S., and Grosskreutz, D. C.: Clinical Experience with Fluothane—1400 Cases, ANESTHESIOLOGY 19: 197 (March–April) 1958.
6. Raventos, J.: Action of Fluothane—New Volatile Anaesthetic, Brit. J. Pharmacol. 11: 394 (Dec.) 1956.
7. Bryce-Smith, R., and O'Brien, H. D.: Fluothane, Non-Explosive Volatile Anaesthetic Agent, Brit. Med. J. 2: 969 (Oct. 27) 1956.
8. Dobkin, A. B.: Evaluation of Ventilator with Fixed Volume Control and Variable Regulated Pressure, Canad. Anaesth. Soc. J. 5: 288 (July) 1958.
9. Dobkin, A. B.: Regulation of Controlled Respiration: Recent Concepts Important to Anaesthetist, Brit. J. Anaesth. 30: 282 (June) 1958.
10. Hall, K. D., and Norris, F. H., Jr.: Respiratory and Cardiovascular Effects of Fluothane in Dogs, ANESTHESIOLOGY 19: 339 (May–June) 1958.
11. Devine, J. C., Hamilton, W. K., and Pittinger, C. B.: Respiratory Studies in Man During Fluothane Anesthesia, ANESTHESIOLOGY 19: 11 (Jan.–Feb.) 1958.
12. Burnap, T. K., Galla, S. J. and Vandam, L. D.: Anesthetic, Circulatory and Respiratory Effects of Fluothane, ANESTHESIOLOGY 19: 307 (May) 1958.
13. Nealon, T. F., Jr., Chase, H. F., and Gibbon, J. H., Jr.: Factors Influencing Carbon Dioxide Absorption During Anesthesia, ANESTHESIOLOGY 19: 75 (Jan.–Feb.) 1958.