Ventilatory Effects of Isoflurane: A Comparison with Halothane in a Draw-Over System

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SUMMARY: Halothane and isoflurane were studied using a draw-over anaesthetic system in two groups each of 25 patients to compare the ventilatory effects of the two agents in field anaesthesia. Respiratory variables were measured and it was confirmed that isoflurane is a more potent respiratory depressant than halothane, but satisfactory anaesthesia for short procedures was possible.

Introduction

The Triservice Anaesthetic Apparatus is a draw-over system using ambient air and the primary carrier gas¹. Currently only halothane and trichloroethylene are scaled for use in the field by the British Forces. Halothane alone or in combination with trichloroethylene in spontaneously breathing patients has been found to be most satisfactory². Isoflurane, however, would appear to be a suitable anaesthetic agent for use in a draw-over system, because of its low blood/gas solubility which leads to a rapid induction and recovery, lack of *in vivo* metabolism and cardiovascular stability. The effects of an anaesthetic agent on breathing are of clinical importance. We set out, therefore, to compare the respiratory variables of both agents as they would be used in the field. The study was approved ethically by the Army Medical Services Research Executive.

Materials and Methods

Two groups of 25 patients belonging to ASA Class I were studied. As can be seen in Table 1, the groups were comparable with regard to age, sex, weight, smoking habits and duration of surgery. The surgical procedures were those that were not expected to last more than half an hour and were suitable for employment of a spontaneous ventilation technique using a face mask. The concentration of the volatile agent was adjusted to the minimum compatible with satisfactory anaesthesia.

The patients were studied in chronological groups in preference to random selection in order to avoid the need to adjust measuring equipment repeatedly for each

agent. Patients who had had a recent halothane anaesthetic were given isoflurane. Premedication with pethidine 75-100 mg and atropine 0.6 mg was given intramuscularly approximately one hour before induction. Thiopentone 350-500 mg was used for induction. Inhalation anaesthesia was started immediately and an oropharyngeal airway was introduced as soon as the depth of anaesthesia allowed. A gas sampling catheter was placed at the top of the oropharyngeal airway. The patients were connected to the monitoring equipment. Carbon monoxide concentration, volatile agent concentration and tidal volume

Table 1
Details of patients and duration of surgery.
(Mean $\pm$ SEM) (Range)

	Halothane	Isoflurane
Age (Yrs)	31.04 $\pm$ 1.28 (18-41)	29.8 $\pm$ 1.26 (18-43)
Sex	19M; 6F	18M; 7F
Weight (Kg)	79.79 $\pm$ 1.8 (63-101)	76 $\pm$ 1.96 (60-95)
Smoking Habits	11: 14	12: 12
Smokers:		(1 unknown)
Non-Smokers		
Duration of Surgery (Mins)	12.8 $\pm$ 1.16 (5-27)	16.08 $\pm$ 1.44 (6-33)

were recorded continuously. Tidal volume was measured with a BOC Wright's electronic spirometer on the expiratory side of the patient non-return valve. The spirometer had been calibrated with a known volume. Carbon dioxide concentration was measured with a Datex infrared analyzer CD 102-22-02 which had been calibrated against BOC special gases (carbon dioxide 10%, oxygen 15%, nitrogen 75%). Volatile agent concentrations were measured with a Datex infrared anaesthetic monitor AA 101-21-01 which had been calibrated using a Riken refractometer 18 with halothane scale. The outputs of this equipment were continuously recorded on a Siemens Elema Mingograf 34T recorder. The recovery time was taken to be the interval between the end of surgery and response to simple commands.

A three minute period of the trace during stable anaesthesia was analysed taking care to avoid periods of

marked surgical stimulation. The data was analysed using unpaired Students' *t* test.

Results

The results of the measurements of the respiratory rate, tidal volume, end-tidal carbon dioxide, recovery time and duration of surgery are given in Table 2 for halothane and in Table 3 for isoflurane. A statistical summary for both is given in Table 4. There was a marked difference in the respiratory rates between the agents. Halothane invariably produced a tachypnoea which proved statistically highly significant ($p < 0.01$). The mean tidal volume of the halothane group was greater than the mean tidal volume in the isoflurane group. The difference was significant ($p < 0.05$). The mean minute volume in the halothane group was greater than that of the isoflurane group. The difference was highly significant ($p < 0.01$).

Table 2
Results of patients anaesthetised with halothane.

Serial No.	Sex	Weight kg	Age yrs	Resp Rate per min	End-Tidal Carbon dioxide KPa	Tidal Volume ml	Recovery Time min	Duration of Surgery min
51	M	79	23	26	7	260	12	16
52	M	82.06	30	40	5.5	300	21	16
53	M	76.2	40	23	7	360	25	27
54	M	65	36	26	6.6	210	21	18
55	M	72.27	24	22	6.5	410	18	14
56	M	68	35	24	6.25	350	20	13
57	F	69	31	24	5.5	195	12	6
58	F	71	27	26	5.625	320	17	6
59	F	101	24	31	6.9	230	12	6
60	M	66	37	30	6.31	350	14	13
71	M	80.5	31	22	7.6	320	22	16
72	M	88	41	31	7.3	305	6	7
73	M	70	30	25	7	270	15	14
74	M	77.83	33	21	7.2	225	10	8
75	M	76.92	32	19	7.6	250	31	16
76	M	70	27	17	8.0	270	18	23
77	M	94	38	40	6.8	200	12	19
91	M	85	26	24	6.7	220	22	7
96	M	76	18	33	7.76	240	11	12
97	M	72	31	34	6.2	240	20	14
99	M	76.02	40	24	6.5	220	9	14
100	M	69	19	19	7.8	280	15	17
163	F	67.5	35	21	4.8	300	11	6
164	F	79.5	38	25	6.0	260	11	5
167	F	63	30	31	6.0	300	7	7

Table 3
Results of patients anaesthetised with isoflurane.

Serial No.	Sex	Weight kg	Age yrs	Resp Rate per min	End-Tidal Carbon dioxide KPa	Tidal Volume ml	Recovery Time min	Duration of Surgery min
61	M	78.18	26	20	6.06	220	20	12
62	M	85	28	24	6.8	160	7	11
64	M	65	28	17	6.8	300	12	33
65	M	78.84	32	17	8.2	220	15	13
66	M	85	38	18	8.6	220	9	28
67	F	60	29	17	6.4	300	12	15
68	M	69	35	18	7.8	200	11	17
69	F	85	35	15	8.5	370	14	10
70	F	63	24	21	7.4	240	18	6
81	F	84	39	19	6.6	370	19	16
82	M	77.5	28	14	8.4	200	21	13
83	M	73	20	17	8.7	230	10	20
84	M	80.5	31	19	7.8	205	5	28
85	F	70	30	30	7.9	210	7	8
86	M	95	33	27	6.9	250	23	13
87	M	67.5	28	21	7.8	280	19	16
88	F	63	26	18	7.5	180	19	7
89	M	80	35	20	7.4	225	15	14
90	M	86	43	20	7.6	270	15	12
101	M	76	22	19	7.8	175	2	23
102	M	66.6	18	20	7.9	280	10	17
103	M	85	19	22	8.0	230	4	29
104	M	90.5	29	25	6.6	200	7	13
108	M	85	36	14	7.9	240	7	19
113	F	63	33	18	6.4	260	11	9

The mean end-tidal carbon dioxide concentration in the isoflurane group was higher than that of the halothane group and this difference was highly significant ($p < 0.01$). The mean recovery time appeared to be shorter for isoflurane than for halothane but the difference did not reach statistical significance. Mean agent concentrations of halothane and isoflurane were $0.74\% \pm 0.03$ (Range 0.4–1.1) and $1.18\% \pm 0.04$ (Range 0.8–1.5) respectively.

Discussion

The Wright's spirometer tends to be inaccurate at low flow rates³ but it has been shown that this is not clinically significant unless the minute volume falls below 2.4 litres⁴. The simpler measurement of end-tidal carbon-dioxide tension was preferred to invasive measurement of arterial carbon dioxide tension. Nunn and Hill⁵ showed evidence that during anaesthesia in fit subjects

there is a sufficiently constant relationship between arterial and end-tidal carbon dioxide tensions regardless of the manner or the depth of respiration.

The results of this study show that isoflurane is a more potent respiratory depressant than halothane. Our results seem to reflect the observation of Fourcade et al⁶ in that the respiratory depression of isoflurane resulted from a unique failure of the respiratory frequency to increase. Substitution of nitrous oxide for an equal minimum alveolar concentration fraction of a potent agent would decrease the respiratory acidosis produced by the potent agent⁷. In the draw-over system of anaesthesia, with air as the only vehicle for a volatile anaesthetic agent, the respiratory depressive effect of isoflurane is more marked. Eger⁷ concluded that the presence of surgical stimulation and nitrous oxide reduces the hypercapnoea caused by isoflurane. As might be expected from Eger's work, our isoflurane

Table 4
Statistical summary of results from both agents
(Mean + SEM)

	Halothane	Isoflurane	p
Respiratory Rate f (b.p.m.)	26.32 ± 1.2	19.6 ± 1.16	<0.01
Tidal volume (ml)	275.4 ± 11.1	241.4 ± 10.67	<0.05
Minute volume (litre min ⁻¹)	7.2 ± 0.47	4.65 ± 0.24	<0.01
End tidal carbon dioxide (%)	6.66 ± 0.16	7.51 ± 0.15	<0.01
Recovery time (min)	15.84 ± 1.2	12.48 ± 1.16	NS

f = Frequency

bpm = Beats per minute

NS = Not significant

group shows a relative hypercapnoea. It has been shown previously that, with halothane as the main anaesthetic agent, arterial carbon dioxide tensions can rise to 9KPa but without any demonstrable harm to the patient^{5,8}. Our patients showed no adverse effects.

In conclusion it appears that isoflurane causes a greater degree of respiratory depression than halothane,

but under the conditions of this study satisfactory anaesthesia with isoflurane is possible for short procedures without any adverse effect.

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