Minute ventilation during mask halothane anaesthesia in infants and children

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The pattern of respiration in infants during anaesthesia is not well documented. In this study, minute ventilation (MV) during elective mask halothane anaesthesia (HA) was measured during spontaneous ventilation in infants (Group I) and children (Group II). Airflow was measured with pneumotachography (#0 Fleisch in Group I and #1 Fleisch in Group II). Analogue signals of pressure and flow were recorded on magnetic tape for off-line playback. The flow signal was mathematically integrated to volume. The surgical procedure was divided into three stages: A, B and C representing HA, surgical stimulation and emergence respectively. The pattern of respiration during spontaneous ventilation was described as tidal volume (VT_X), respiratory frequency (f_X), mean inspiratory flow (VT/TI_X), inspiratory duty cycle ($TI/TTot_X$) where the subscript x denoted the stage. Seven infants (2.7 ± 0.5 mo, 5.8 ± 0.5 kg) and five children (3.1 ± 1.1 yr, 15.8 ± 1.7 kg) were studied. There was no difference in MV between Groups I and II. Halothane anaesthesia in both groups was characterized by rapid shallow breathing: VT_A was lower in Group I (2.90 ± 0.8 $ml \cdot kg^{-1}$) than in Group II (3.74 ± 0.40 $ml \cdot kg^{-1}$) ($P < 0.05$). Tidal volume was lower during anaesthesia than emergence in both groups ($P < 0.05$). There was no difference in VT/TI_X between groups. The VT/TI_A was lower than VT/TI_C in Group I ($P < 0.05$) but not in Group II. There was no intra or intergroup difference in TI/TTot between stages. We suggest that during HA infants have a greater reduction in VT than children, which may predispose infants to hypercarbia during HA.

Key words
ANAESTHESIA: paediatric;
ANAESTHETICS, VOLATILE: halothane;
VENTILATION: anaesthetics, effect of.

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Les caractéristiques ventilatoires du nourisson pendant l'anesthésie sont mal définies. Au cours de la présente étude, la ventilation-minute (MV) pendant l'anesthésie à l'halothane (HA) au masque pour chirurgie non urgente est mesurée sous ventilation spontanée chez des nourissons (groupe I) et des enfants (groupe II). Le débit respiratoire est mesuré par pneumotachographie (Fleisch #0 pour le groupe I, Fleisch #1 pour le groupe II). L'affichage analogique de la pression et du débit est enregistré sur ruban magnétique pour analyse ultérieure. Le signal du débit respiratoire est intégré mathématiquement à celui du volume. L'intervention chirurgicale est divisée en trois stages : A, B, et C lesquels représentent respectivement : HA, la stimulation chirugicale et la période du réveil. Les variables propres à la ventilation spontanée comprennent le volume courant (VT_X), la fréquence respiratoire (fx), le débit inspiratoire moyen (VT/TI_X) et la durée du cycle inspiratoire ($TI/TTot_X$) où l'indice X correspond au stage. Sept nourissons (2,7 ± 0,5 mois, 5,8 ± 0,5 kg) et cinq enfants (3,1 ± 1,1 ans, 15,8 ± 1,7 kg) font partie de l'étude. On ne retrouve pas de différence de MV entre les groupes I et II. L'anesthésie à l'halothane est caractérisée dans les deux groupes par une respiration superficielle rapide; le VT_A est plus bas dans le groupe I (2,90 ± 0,8 $ml \cdot kg^{-1}$) que dans le groupe II (3,74 ± 0,40 $ml \cdot kg^{-1}$) ($P < 0,05$). Le volume courant est moins élevé pendant l'anesthésie qu'à la période de réveil dans les deux groupes ($P < 0,05$). Il n'y a pas de différence pour le rapport (VT/TI_X) entre les groupes. Le VT/TI_A est inférieur au VT/TI_C dans le groupe I ($P < 0,05$) mais non dans le groupe II. Il n'y a pas de différences à l'intérieur d'un groupe ou entre les groupes pour le TI/TTot si on compare les stages. Ces résultats suggèrent que pendant HA, les nourissons subissent une plus grande réduction du VT que les enfants, ce qui peut prédisposer les nourissons à l'ypercarbie sous anesthésie spontanée à l'halothane.

Values for minute ventilation (MV) in spontaneously breathing anaesthetized infants are not well documented. This is, in part, because studies investigating MV during anaesthesia group infants with children and normalize ventilation data on a per kg basis.[1-4] The purpose of this study was to characterize and compare MV during

halothane anaesthesia (HA) in infants and children. The tachypnoea of HA has been shown experimentally to be due to a central effect of halothane on the brainstem which reduces the duration of inspiration (TI). In addition, halothane-induced stimulation of irritant lung receptors may, through vagally mediated mechanisms, shorten TI. The aetiology of the shallow breathing characteristic of HA is thought to be multifactorial including: (1) the shortening of TI; (2) a reduction in ventilatory drive and (3) an impairment in respiratory mechanics.[5-7] One could hypothesize that halothane might affect the immature respiratory system of the infant differently from the adult and the child. We thought that a study of breathing patterns during HA in infants might be helpful to delineate the specific anaesthetic considerations of infants undergoing general anaesthesia.

Methods

The protocol was approved by the Ethics Committee on Human Experimentation and informed parental consent was obtained. Twelve healthy fasted children, ASA physical status I, undergoing elective herniorrhaphy were studied. Prematurity was considered an exclusion criterion. Patients were grouped according to age. Group I comprised infants aged 2 to 4 mo, and Group II comprised children aged 2 to 5 yr.

Premedication was not given. Anaesthesia was induced with thiopentone (5 $mg \cdot kg^{-1}$) or halothane and was maintained with 70% N_2O in oxygen at an inspired concentration of 2% in Group I and 2.5% in Group II. All patients received atropine (0.02 $mg \cdot kg^{-1}$). Anaesthesia was delivered via a Mapleson D anaesthetic circuit using a fresh gas flow of 12 $L \cdot min^{-1}$. Resistance of the apparatus produced 1 cm H_2O at a 12 $L \cdot min^{-1}$ flow. In these patients, whose tracheas were not intubated, breathing was spontaneous through a modified Jackson Rees circuit with a scavenger attachment. An oropharyngeal airway was placed in all patients. An ilioinguinal field block with bupivicaine (0.25%) was performed by the surgeon during closure of the surgical wound to provide postoperative analgesia. During emergence from anaesthesia, the nitrous oxide was discontinued and the child breathed 100% oxygen. The child was not disturbed during emergence from anaesthesia. Spontaneous movement of an extremity marked the end of the signal record.

Mouth pressure (Microswitch #142PC050) and flow (Fleish #0 (Group I) or #1 (Group II) pneumotachograph Microswitch #163PC1D36) were measured. Both pneumotachographs were calibrated with the two gas mixtures used during the surgical procedure namely (1) 70% N_2O in oxygen and (2) 100% oxygen and were linear over the range of flows observed. The flow calibration was verified with a volume calibration at the beginning and end of each study. The coefficient of variation for repeated volume measures was 2%.

The signals were recorded on a Hewlett Packard four-channel magnetic tape recorded for off-line playback through a 12-bit A to D board (Data Translation DT2801-A, Mississauga, Ontario, Canada). During playback, signals were sampled at 50 Hz and recorded on an IBM computer for off-line analysis (Anadat©, RHT-Infodat, Montreal, Canada). The flow signal was zero offset, drift corrected and mathematically integrated to volume. Signals underwent breath-by-breath analysis. Breaths showing evidence of a poor mask fit from the pressure and flow signals were discarded.

The surgical procedure was divided into three stages: A, B and C where stage A was pre-incision, stage B was during ligation and division of the hernia sac and stage C was emergence. Stage A represented steady state HA, ten minutes after induction and before the confounding variable of painful surgical stimulation was introduced. Stage B introduced the confounding variable of a painful stimuli on the background of HA. Stage C represented recovery from HA. Since emergence spanned a period of about ten minutes, Stage C was represented by data sampled during the minute preceding spontaneous movement of the child (Figure 1).

Values for MV_X, VT_X, $TI/TTot_X$ and VT/TI_X were expressed on a per kg basis, where the subscript X refers to the stage, A, B or C, TI/TTot is the inspiratory duty cycle, VT is tidal volume, VT/TI is the mean inspiratory flow.

It was not possible to coax fasted unpremedicated infants or children to breath quietly from the mask for control values of resting MV. Therefore, the predicted resting minute ventilation (MRV_{PRED}) for each patient was derived from the Power Law prediction for minute ventilation in mammals:[8]

$$MRV_{PRED} = aBW^b \quad \text{(Eq. 1)}$$

LIST OF ABBREVIATIONS

The subscript X denotes the stage A, B or C

- f_X – Respiratory frequency
- MV_X – Minute ventilation ($VT/TI_X \times TI/TTot_X \times 60$)
- TE_X – Expiratory time
- TI_X – Inspiratory time
- $TI/TTot_X$ – Inspiratory duty cycle
- $TTot_X$ – total time of a respiratory cycle ($T_I + T_E = T_{Tot}$)
- VT_X – Tidal volume
- VT/TI_X – Mean inspiratory flow
- $P_{ET}CO_2$ – End tidal partial pressure CO_2

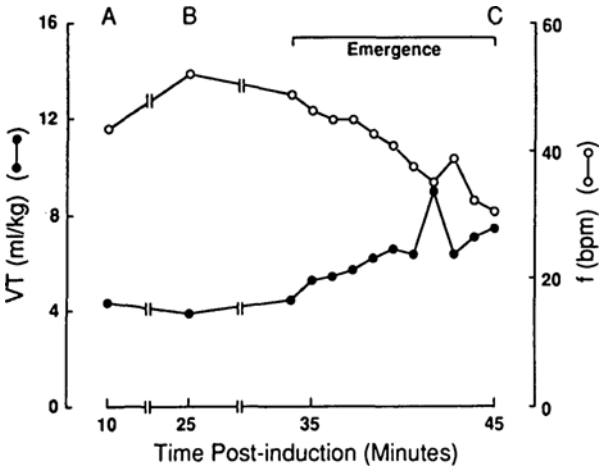

FIGURE 1 The course of a representative study. The changes in VT and f in a representative patient during the course of the study are shown. Each data point represents the mean value of 30s of representative data. The abscissa plots time post-induction of anaesthesia in minutes and relates it to the stage. The ordinate axes plot VT and f.

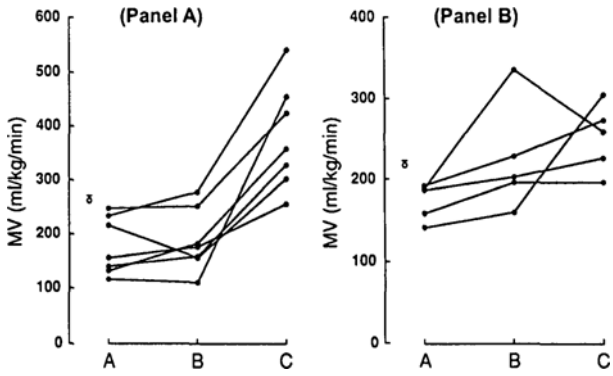

FIGURE 2 Values of MV_X for individual patients during each stage in Group I (Panel A) and Group II (Panel B). MRV_{PRED} for the Group (X ± SD) is indicated in the left hand margin of the figure.

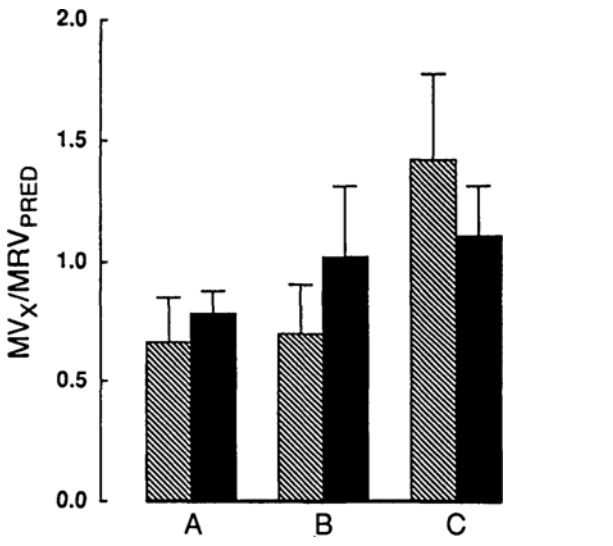

FIGURE 3 The ratio MV_X/MRV_{PRED} for each stage in Group I (hatched) and Group II (solid). Standard deviations are shown. There was no statistical difference between groups.

where the constant a = 379, the exponent b = 0.8 and BW is body weight in kg. The ratio of MV_X/MRV_{PRED} was calculated for each stage.

The predicted tidal volume (VT_{PRED}) was taken to be the interspecies constant for mammals (VT_{PRED} = 7.69 ml · kg^{-1}).[9] The predicted value for the inspiratory duty cycle TI/TTot was taken to be the interspecies constant of 0.345 ± 0.051.[8]

The predicted value for VT/TI (VT/TI_{PRED}) was derived from the power low prediction for VT/TI in mammals:[9]

$$\log VT/TI = 0.738 \log BW + 1.35$$
$$VT/TI = 1.35\ BW^{0.74} \quad \text{(Eq. 2)}$$

where BW is the body weight in kg.

Statistical analysis

Intergroup differences between MV_X/MRV_{PRED} and control were assessed with Nonparametric Wilcoxon Ranked Sign test, where control MV_X/MRV_{PRED} = 1. Intragroup differences were assessed with Nonparametric Wilcoxon ANOVA.[10]

Results

Seven infants in Group I (2.7 ± 0.5 mo, 5.8 ± 0.5 kg) and five children in Group II (3.1 ± 1.1 yr, 15.8 ± 1.7 kg) were studied. No patient moved with surgical incision.

The course of a representative study is shown in Figure 1. The abscissa plots time post-induction of anaesthesia and stage A, B and C and relates them to the value for VT and f on each ordinate axis. The MRV_{PRED} in Group I was 267.03 ± 5.03 ml · kg^{-1} · min^{-1} and in Group II was 218.41 ± 4.05 ml · kg^{-1} · min^{-1}. The MV_A in Group I was 177.7 ± 53.9 ml · kg · $^{-1}$ · min^{-1}, a value which was not different from the MV_A in Group II of 173.7 ± 22.0 ml · kg^{-1} · min^{-1} (Table I, Figures 2, 3).

The MV_B in Group I was 187.5 ± 58.5 ml · kg^{-1} · min^{-1} and was 224 ± 66.9 ml · kg^{-1} · min^{-1} in Group II. The MV_C in Group I was 380.4 ± 97.8 ml · kg^{-1} · min^{-1} and in Group II was 248.9 ± 41.6 ml · kg^{-1} · min^{-1}.

Table II summarizes the values for VT, f, VT/TI, TI/TTot and TI during stages A, B and C. The value for

TABLE I Demographic data for individual patients values for MV_{PRED}, MV_X and MV_X/MRV_{PRED} are given. An asterisk (*) indicates intragroup statistical difference from stage A ($P < 0.05$). The symbol (‡) indicates intergroup statistical significance ($P < 0.05$)

				Stage A		*Stage B*		*Stage C*	
Pt.	*Age*	*Wt (kg)*	MRV_{PRED} ($ml \cdot kg^{-1} \cdot min^{-1}$)	MV ($ml \cdot kg^{-1} \cdot min^{-1}$)	MV_A/MRV_{PRED}	MV ($ml \cdot kg^{-1} \cdot min^{-1}$)	MV_B/MRV_{PRED}	MV ($ml \cdot kg^{-1} \cdot min^{-1}$)	MV_C/MRV_{PRED}
Group I	*(mo)*								
1	3.0	6.6	259.85	156.80	0.60	175.08	0.67	256.11	0.99
2	3.0	6.0	264.86	140.70	0.53	157.90	0.60	327.70	1.24
3	2.0	5.0	274.69	247.60	0.90	253.00	0.92	424.80	1.55
4	3.0	5.8	266.66	216.50	0.81	156.20	0.59	302.60	1.14
5	3.0	5.9	265.75	131.20	0.49	181.83	0.68	358.50	1.35
6	3.0	5.2	272.55	234.90	0.86	278.10	1.02	539.00	1.98
7	2.0	6.0	264.86	116.20	0.44	110.40	0.42	454.20	1.72
X	2.70	5.80	267.03	177.70	0.66	187.50	0.70	380.40*	1.42*
±SD	0.52	0.54	5.03	53.90	0.19	58.50	0.21	97.80	0.35
Group II	*(yr)*								
1	2.0	15.0	220.51	186.50	0.85	202.30	0.92	225.45	1.02
2	2.5	16.0	217.68	192.26	0.88	228.10	1.05	272.55	1.25
3	2.0	16.0	217.68	159.33	0.73	196.27	0.90	195.78	0.90
4	3.5	14.0	223.57	188.32	0.84	336.15	1.50	257.37	1.15
5	4.5	18.0	212.61	141.89	0.67	160.16	0.75	303.45	1.43
X	3.1	15.8	218.41	173.70	0.79	224.00	1.02*	248.90*‡	1.15*
±SD	1.1	1.7	4.05	22.00	0.09	66.90	0.29	41.60	0.21

VT_A in Group I was 2.9 ± 0.80 $ml \cdot kg^{-1}$. In Group I VT_B was unchanged (2.9 ± 0.90 $ml \cdot kg^{-1}$). In this group respiratory frequency f_B increased to 68 ± 14 bpm ($P < 0.05$). During HA, VT_A and VT_B were higher in Group II with the value of VT_A = 3.74 ± 0.40 $ml \cdot kg^{-1}$ ($P < 0.05$). During emergence from HA, VT increased in all patients in both groups such that in Group I VT_C was 6.6 ± 1.5 $ml \cdot kg^{-1}$ and in Group II VT_C was 7.1 ± 1.4 $ml \cdot kg^{-1}$ ($P < 0.05$) (Figure 4).

The VT/TI_{PRED} in Group I was 14.15 ± 0.39 $ml \cdot kg^{-1} \cdot sec^{-1}$ and in Group II was 10.88 ± 0.26 $ml \cdot kg^{-1} \cdot sec^{-1}$. In Group I the values of VT/TI_A and VT/TI_B were 8.0 ± 1.94 $ml \cdot kg^{-1} \cdot sec^{-1}$ and 8.4 ± 2.10 $ml \cdot kg^{-1} \cdot sec^{-1}$ respectively. During emergence in Group I VT/TI_C increased in all infants to a mean of 16.7 ± 4.7 $ml \cdot kg^{-1} \cdot sec^{-1}$ ($P < 0.05$). In Group II the value for VT/TI_A tended to be lower than VT/TI_C but the difference did not reach statistical significance. There was no difference in the ratio TI/TTot between or within groups.

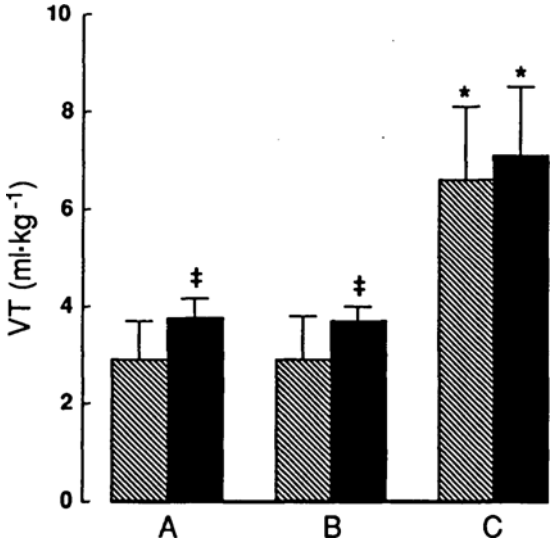

FIGURE 4 This histogram (X ± SD) summarizes group values for VT_X during HA and recovery in both groups. During HA VT_A and VT_B were lower than VT_C in both groups ($P < 0.05$). During HA VT_A and VT_B were lower in Group I (hatched) than in Group II (solid). ($P < 0.05$) There was no difference in VT_C between groups. The asterisk (*) indicates intragroup statistical difference from stage A ($P < 0.05$). The symbol (‡) indicates intergroup statistical difference from Group I ($P < 0.05$).

Discussion

Comparison of MV during Stage A (HA) and Stage C (emergence) showed that MV was lower ($P < 0.05$) during HA in both infants and children. This finding is consistent with observations during HA in adults and

TABLE II Values for VT_X, F_I, VT/TI_X, $TI/TTot_X$, and T_I. The asterisk (*) indicates intragroup statistical difference from stage A ($P < 0.05$). The symbol (‡) indicates intergroup statistical difference from group I ($P < 0.05$)

	Stage A					*Stage B*					*Stage C*				
	VT (ml · kg⁻¹)	*f* (bpm)	*VT/TI* (ml · kg⁻¹ · min⁻¹)	*TI/TTot*	*TI* (s)	*VT* (ml · kg⁻¹)	*f* (bpm)	*VT/TI* (ml · kg⁻¹ · min⁻¹)	*TI/TTot*	*TI* (s)	*VT* (ml · kg⁻¹)	*f* (bpm)	*VT/TI* (ml · kg⁻¹ · min⁻¹)	*TI/TTot*	*TI* (s)
Group I															
1	2.20	61.0	6.5	0.40	0.40	2.40	72.0	7.7	0.38	0.31	7.30	35.0	9.8	0.44	0.74
2	2.80	51.0	6.2	0.34	0.40	2.50	64.0	8.1	0.32	0.30	4.70	70.0	14.3	0.38	0.33
3	3.10	80.0	11.6	0.36	0.26	2.80	90.0	11.0	0.38	0.26	5.80	73.0	18.6	0.38	0.31
4	3.20	69.0	8.6	0.42	0.37	2.60	83.0	6.2	0.42	0.31	5.00	61.0	13.9	0.36	0.26
5	2.50	53.0	6.8	0.32	0.37	3.10	60.0	9.5	0.32	0.32	8.10	44.0	19.6	0.31	0.41
6	4.50	51.0	9.3	0.42	0.48	4.80	53.0	10.8	0.43	0.50	8.60	63.0	24.3	0.37	0.35
7	2.10	55.0	7.1	0.27	0.30	2.00	54.0	5.6	0.33	0.29	6.50	70.0	16.6	0.46	0.39
X	2.90	60.1	8.0	0.36	0.37	2.90	68.0*	8.4	0.37	0.37	6.60*	59.4	16.7*	0.39	0.40
±SD	0.80	11.0	1.9	0.06	0.07	0.90	14.0	2.1	0.04	0.08	1.50	14.5	4.7	0.05	0.16
Group II															
1	4.30	44.0	8.9	0.35	0.48	3.90	52.0	8.4	0.40	0.47	7.40	31.0	10.4	0.36	0.71
2	3.90	49.0	9.9	0.32	0.37	4.00	57.0	10.6	0.36	0.38	6.90	40.0	14.0	0.32	0.40
3	3.80	42.0	8.7	0.31	0.44	3.80	53.0	10.7	0.31	0.35	6.00	33.0	7.9	0.41	0.76
4	3.30	58.0	8.5	0.37	0.38	3.70	90.0	14.9	0.38	0.25	5.80	43.0	12.3	0.34	0.46
5	3.40	42.0	6.3	0.37	0.53	3.30	49.0	6.6	0.40	0.50	9.40	32.0	11.7	0.43	0.73
X	3.74‡	47.0‡	8.5	0.40	0.44	3.70‡	60.2*	10.2	0.37	0.39	7.10*	37.8‡	11.3	0.37	0.61
±SD	0.40	06.8	1.3	0.08	0.07	0.30	16.9	3.1	0.04	0.10	1.40	5.5	2.3	0.05	0.17

in children. The value for MV_A in Group I (177.70 ± 53.90 ml · kg⁻¹ · min⁻¹) was not different from MV_A in Group II (173.7 ± 22.0 ml · kg⁻¹ · min⁻¹). Reported values for MV during HA range from 106 to 120 ml · kg⁻¹ · min⁻¹.[1-4] However, it is difficult to compare our results with these studies because of differences in methodology and important aspects of study design, namely the use of premedication and different depths of anaesthesia. In addition studies in the literature involved children of dissimilar ages which presents a problem when ventilation data is normalized on a per kg basis.

Extensive investigations have shown that when normalized to body weight, small mammals have a higher metabolic rate than larger mammals. Since alveolar ventilation is closely coupled to metabolic rate, it follows that, resting minute ventilation, when normalized to body weight, is higher in infants than in adults.[11] The validity of our value of MRV_{PRED} in infants (Group I) is supposed by the work of Haddad[12] who measured MV in sleeping infants and found an instantaneous MV of 20–25 ml · sec⁻¹ which in a 5 kg two-to-three-month-old infant would be about 240–300 ml · kg⁻¹ · min⁻¹. This range is in good agreement with our MRV_{PRED} of 267.03 ± 5.03 ml · kg⁻¹ · min⁻¹ in Group I. No comparable values for resting minute ventilation in sleeping children are available to validate MRV_{PRED} in Group II of 218.41 ± 4.05 ml · kg⁻¹ · min⁻¹. It was expected that MV_X should be higher in Group I than Group II. This expectation was only seen in Stage C ($P < 0.05$). During HA, MV_A was similar in both groups.

The ratio MV_X/MRV_{PRED} was used to factor in the difference in MRV_{PRED} when normalized to body weight. It is noteworthy that during emergence MV_C/MRV_{PRED} exceeded unity in both groups. This may have indicated the influence of painful stimuli on minute ventilation. MV_X/MRV_{PRED} was lower during HA than emergence in both groups ($P < 0.05$). There was no intergroup difference although the ratio MV_A/MRV_{PRED} of 0.66 ± 0.19 in Group I was lower than the value of 0.79 ± 0.09 in Group II.

Discussion of the effect of halothane on MV must consider the concentration of halothane used. Clinical experience had shown that infants (Group I) required an inspired halothane concentration of 2% and the children (Group II) required an inspired halothane concentration of 2.5% for herniorrhaphy. The minimum alveolar concentration (MAC) for halothane in infants aged two to three months ranges from 1.08% to 1.2%[13-15] whereas MAC for halothane in children two to five years ranges from 0.91 to 1.07%.[13,15] Therefore, for Group I the halothane MAC multiple (% halothane/MAC) was around 1.7. For Group II the halothane MAC multiple was

around 2.6. Consideration of the slower uptake of halothane in Group II, which at ten minutes after induction of anaesthesia would give an expired to inspired halothane concentration (F_E/F_I) ratio of 0.6 in Group II and 0.7 in Group I, would lower the Stage A MAC multiple to 1.6 and 1.2 respectively.[16] Our study design might have biased Group II to have a deeper plane of anaesthesia and a greater degree of respiratory depression.

Stage B introduced the confounding variable of surgical stimulation; it resulted in an increase in MV_B/MRV_{PRED} in Group II ($P < 0.05$) but no increase in Group I.

Analysis of MV into its components of tidal volume and frequency showed several features. Firstly, in Stage C there was no difference in VT_C between groups and in both groups VT_C approximated the predicted VT of 7.69 ml · kg^{-1}.[9] Both groups showed a reduction in VT during HA (Stage A) ($P < 0.05$). Neither group showed an increase in VT_B during surgical stimulation. However, VT_A and VT_B were lower in infants (2.9 ml · kg^{-1}) than in children (3.7 ml · kg^{-1}) ($P < 0.05$). The lower VT during HA in Group I may have clinical importance suggesting a substantive predisposition for carbon dioxide retention in infants. As expected, respiratory frequency was higher in infants than children during Stage A and Stage C ($P < 0.05$). Only Group II showed an increase in respiratory frequency during HA ($P < 0.05$). During maximal surgical stimulation both groups showed an increase in f_B ($P < 0.05$).

Minute ventilation has also been expressed as the product of mean inspiratory flow (VT/TI) and the ratio TI/TTot:

$$MV = VT/TI \times TI/TTot.$$

such that VT/TI has been interpreted as an index of central drive and TI/TTot is an index of timing.[7,17,18]

The inspiratory duty cycle (TI/TTot) has been used as an index of the switching mechanism between the medullary inspiratory and expiratory motoneurons.[7,17,18] The values of $TI/TTot_A$ in Groups I and II (0.37 ± 0.06 and 0.34 ± 0.03 respectively) were not different and were within one standard deviation of the interspecies constant of 0.345 ± 0.051.[5]

Mean inspiratory flow (VT/TI) has been used as a variable of ventilatory drive. In Group II there was no difference in VT/TI_X in any stage suggesting that ventilatory drive was not depressed during HA. This finding is curious since it agrees with a study in adults which suggested that methoxyflurane did not depress ventilatory drive – that is that the neural output of the medullary ventilatory centre was not depressed during methoxyflurane anaesthesia.[19] In Group I VT/TI_A was lower than VT/TI_C ($P < 0.05$), suggesting that in contrast to Group II experienced a decrease in ventilatory drive during HA. The VT/TI can also be influenced by changes in respiratory impedance which affect the flow rate generated for a given level of respiratory drive. Further studies which account for the effect of HA on respiratory mechanics are indicated to define the effect of halothane on ventilation in infants.

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