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Title : EFFECT OF ANAESTHESIA ON REBREATHING IN THE BAIN CIRCUIT

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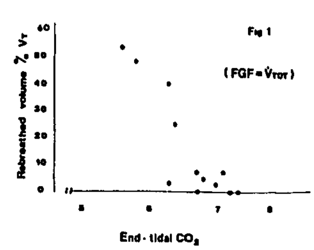
Introduction. For patients breathing spontaneously on the Bain circuit, controversy persists about the use of fresh gas flowrates (FGF) less than the theoretical non-rebreathing flow of over twice minute ventilation proposed by Mapleson.[1] In the present study we have used data from 12 anesthetized patients to calculate the percentage of each breath taken up by rebreathed alveolar gases ($V_R\%V_T$) and will evaluate the effect of this "rebreathing" on minute ventilation ($\dot{V}_E$) and end tidal CO_2 ($F_E'CO_2$).

Methods. Twelve healthy patients aged 6-16 years were the subjects of the study. Written consent was obtained from the parents of all subjects and the study was approved by the Ethics Committee of the institution. Six of the patients were premedicated with pentobarbitone, morphine and hyoscine. Anesthesia was induced with thiopentone followed by succinylcholine for intubation, and was maintained with nitrous oxide, oxygen and halothane 0.5-1.5%. Halothane concentration was selected to give adequate anesthesia and thereafter kept constant. Once spontaneous respiration returned $F_E'CO_2$ and $\dot{V}_E$ were continuously monitored by means of an LB II CO_2 analyser attached close to the end of the endotracheal tube and a Fleish pneumotachograph attached to the distal end of the Bain rebreathing tube. The flow signal from the pneumotachograph was electrically biased to eliminate the constant FGF signal. Values of $\dot{V}_E$ and $F_E'CO_2$ were recorded at FGF of twice predicted minute ventilation (i.e. 2 X $\dot{V}_{Tot}$ calculated from Engstrom Ventilation Tables) after 30 min. of anesthesia. Measurements were then repeated with FGF=$\dot{V}_{Tot}$ and FGF=$0.7\dot{V}_{Tot}$ with 20 min. equilibration time between each flow. Rebreathed volume was calculated from the patient's respiratory flow trace and the FGF by mathematically modeling the respiratory events with the aid of a computer. This volume was then expressed as a percentage of V_T ($V_R\%V_T$). The accuracy of the model was verified by comparing measured V_T to calculated V_T. To compare subjects, minute ventilation was normalised by dividing by $\dot{V}_{Tot}$.

Results. No significant difference was found between the $F_E'CO_2$ at FGF=$2\dot{V}_{Tot}$ when compared to FGF=$\dot{V}_{Tot}$ and FGF=$0.7\dot{V}_{Tot}$ (Table 1). When rebreathing occurred there was a corresponding increase in $\dot{V}_E$. At FGF=$\dot{V}_{Tot}$ most of the rebreathing occurred in the 4 patients with the lowest $F_E'CO_2$ (fig.1,Table 1). In the 8 whose $F_E'CO_2$ was greater than 6.4% mean $V_R\%V_T$ was 3.1±3.0%, there was no significant change in $F_E'CO_2$ and $\dot{V}_E$ was decreased slightly compared with FGF=$2\dot{V}_{Tot}$.

Discussion. The 4 patients with the lowest $F_E'CO_2$ were undergoing operations involving strong surgical stimulation. The patients with $F_E'CO_2$ greater than 6.4% have a mean $\dot{V}_E=0.49\dot{V}_{Tot}$ when FGF=$\dot{V}_{Tot}$ (fig.2). Therefore, our finding of a low value for rebreathing in these subjects is in agreement with Mapleson's original analysis of the relationship between FGF and $\dot{V}_E$ (i.e. when FGF is greater than $2\dot{V}_E$ rebreathing=0). Conversely, in order to preserve a normal $F_E'CO_2$ (5.5%) when FGF=V_{Tot}, a subject must increase his normal minute ventilation by 50% (fig.2). This agrees well with work on conscious volunteers.



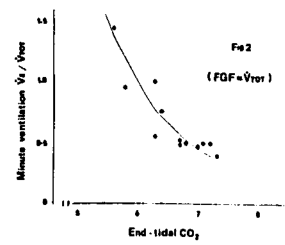


TABLE I

FGF	No. of patients	$V_R\%V_T$	$F_E'CO_2$	$\dot{V}_E/\dot{V}_{Tot}$	%Increase $\dot{V}_E/\dot{V}_{Tot}$
$2\dot{V}_{Tot}$	12	0	6.6±0.3	0.60±0.1	0
$\dot{V}_{Tot}$	12	15.9±20	6.6±0.5	0.68±0.3	10.0
$0.7\dot{V}_{Tot}$	10	27.2±20	6.9±0.6	0.77±0.6	29.9
$2\dot{V}_{Tot}$	4	0	6.4±0.2	0.72±0.07	0
$\dot{V}_{Tot}$	4	41.5±12	6.0±0.4	1.04±0.28	44.4
$2\dot{V}_{Tot}$	8	0	6.8±0.3	0.54±0.04	0
$\dot{V}_{Tot}$	8	3.1±3	6.9±0.3	0.49±0.05	-9.25

Conclusions. Rebreathing in the Bain circuit under anesthesia is governed by the same physical principles as in conscious subjects. However, by depressing the respiratory centre and reducing $\dot{V}_E$, rebreathing may be reduced or abolished during anesthesia. It would seem that significant rebreathing does not occur when $F_E'CO_2$ exceeds 6.4% and FGF=predicted minute ventilation.. Surgical stimulation results in increased V_E and lower $F_E'CO_2$. However, hyperventilation will be quite marked when $F_E'CO_2$ is normal. Our results indicate that during anesthesia with the Bain circuit, if FGF is reduced from 2, to 1 X predicted minute ventilation, any increase in $F_E'CO_2$ is likely to be small and seldom of clinical importance.

References.

1. Mapleson WW: The elimination of rebreathing in various semi-closed anaesthetic systems. Br J Anaesth 26:323-332, 1954