Title: OXYGEN UPTAKE DURING ANESTHETIC WASHOUT

Authors: D.H. Huang, M.D., G. Shigezawa, M.S., M. Gilbert, M.D., J.F. Viljoen, M.D., S. F. Sullivan, M.D.

Affiliation: Department of Anesthesiology, UCLA School of Medicine and The VA Wadsworth Hospital, Anesthesia Service, Los Angeles, California 90024

Introduction:
Post-operative total body oxygen consumption (V_{O2}) increases as inhalational anesthetics are washed out of the body. Sedation and control ventilation are some of the therapy used to minimize this increase in V_{O2}. However, the magnitude and rate at which V_{O2} increases during anesthetic washout are unknown. The purpose of this study is to define V_{O2} alteration during anesthetic emergence.

Method:
12 male postcardiotomy patients, after informed consent, were studied (9 coronary, 3 mitral). Anesthesia consisted of thiopental(3 -5 mg/kg), N_2O/O_2 (50/50), enflurane (0.5-1.5%) and muscle relaxation was provided by either dimethyl tubocurarine or pancuronium chloride. Moderate hypothermia (28-30°C) and enflurane in O_2 were used during cardiopulmonary by-pass. Ventilation(VE) was controlled throughout. Anesthetic concentrations were maintained into the recovery room. In the recovery room, the patients were ventilated with O_2-N_2 mixtures through a volume cycled ventilator(Engstrom ECS 2000). VE and F_iO_2 were matched to those during anesthesia. Exhaled gas was collected in a dry, rolling-seal spirometer and analyzed by a mass spectrometer. V_{O2}, carbon dioxide production (V_{CO2}), anesthetic washout (V_{N2O} and V_{ETH}) were measured. Measurements were taken at 5, 10,15,30,45,60,90,120,150 and 180 minutes post-operatively. Rectal temperature was monitored continuously. During the study period, the patients were sedated with morphine sulfate as required (4-14 mg/3 hours) and the mean arterial blood pressure was maintained between 80 and 90 Torr with Nitroprusside.

Results:
Average body temperature was 35.5°C on arrival in the recovery room and 36.5°C at the end of 3 hours. V_{O2} and V_{CO2} increased following the cessation of anesthesia. The increase in V_{O2} was proportionally larger than that of V_{CO2} initially, this resulted in a gradual decrease in respiratory quotient(RQ); finally approaching steady-state at 60 minutes. The V_{O2} also reached a new level after 60 minutes and showed a maximum of 111.8 ml/m^2/min after 3 hours and at that time the P_aCO_2 and pHa averaged 32 Torr and 7.43. Analysis of the exponential curve that resulted when change in V_{O2} (ΔV_{O2}) was plotted against time showed a total change of 45.1 ml/m^2/min. This represented a V_{O2} of 66.7 ml/m^2/min during general anesthesia. The half time for ΔV_{O2} was 3.3 minutes during the early part of emergence. The N_2O washout from well perfused organs showed a half time of 6.3 minutes while that of enflurane was 12.6 minutes. The data of interest and statistics are summarized in the table:

POSTOP (min)	$VO2/m^2$ ml/m^2/min	$VCO2/m^2$ ml/m^2/min	RQ	TEMP °C
5	84.3*	80.9*	0.98*	35.5*
	4.7	2.8	0.04	0.2
10	91.2*	80.5*	0.92†	35.5*
	4.0	3.1	0.03	0.1
15	96.1*	85.6†	0.85	35.5*
	4.6	4.1	0.03	0.1
30	100.9†	84.3*	0.85	35.5*
	5.7	2.9	0.08	0.1
45	103.4†	84. †	0.82	35.6*
	4.8	3.3	0.02	0.1
60	107.1	86.4	0.81	35.6*
	4.6	3.2	0.02	0.1
90	109.3	86.8†	0.80	35.8*
	3.2	2.4	0.02	0.1
120	110.3	90.5	0.81	35.8*
	3.4	2.5	0.01	0.1
150	111.7	90.6	0.81	36.3*
	3.6	2.2	0.01	0.1
180	111.8	91.6	0.83	36.5
	3.9	2.3	0.05	0.2

$\bar{X} \pm SE$ *P<0.005 †P<.05

Paired t-test compared to the values at 180 minutes.

Discussion:
The low value of VO_2 (66.7 ml/m^2/min) at the end of general anesthesia is not unexpected. This is due to both the depressant effects of emflurane and that of hypothermia. Post bypass hypothermia is well recognized and at 35.5°C can cause a 10% decrease in V_{O2}. The postoperative rise of V_{O2} is rapid and correlates well with the rapid washout of anesthetic. In our series of patients, postoperative V_{O2} is minimized by sedation and mechanical ventilation, thus the V_{O2} after 3 hours is relatively low. However this still represents an increase of 70% from the initial value and the entire increase takes place during the first hour of emergence. Therefore, we conclude that the first hour of emergence is the time of the greatest metabolic change. During this phase of rapid and significant increases in V_{O2}, the patient with low cardiac output and limited O_2 delivery will best be managed by controlled normocapnic ventilation.