Title: CHANGES IN OXYGEN UPTAKE, CARDIAC OUTPUT AND/OR MIXED VENOUS O_2 DIFFERENCE PRODUCED BY AUGMENTING INSPIRED O_2

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Introduction. When inspired O_2 (F_IO_2) is augmented, it is assumed that oxygen uptake ($\dot{V}O_2$), cardiac output ($\dot{Q}t$), or arterial-mixed venous blood oxygen content difference (a-v) remain constant. However, preliminary observations (1) showed significant individual changes in $\dot{V}O_2$, $\dot{Q}t$ and/or a-v. Since intrapulmonary shunt ($\dot{Q}s/\dot{Q}t$) is larger breathing 100% O_2 than breathing a lower F_IO_2, it is desirable to quantify the changes in the variables used for the calculation. Knowledge of the magnitude of these changes is important since they may affect the shunt calculation (2). Thus, the present paper reports the changes in these variables obtained from therapeutic to 100% F_IO_2 as well as the corresponding change in calculated shunt.

Materials and Methods. Twenty patients admitted to the surgical intensive care unit, were in stable condition breathing through an endotrachial tube and with radial and pulmonary artery catheters in place. The F_IO_2 was increased to 100% for 20 minutes from 30, 40, 50, or 60%. The thermodilution technique was used to measure $\dot{Q}t$ using a Gould-Statham $\dot{Q}t$ computer SP1425. Arterial (a) and mixed venous ($\bar{v}$) blood PO_2, PCO_2 and pH were measured with appropriate Radiometer electrodes at 37°C. The values were corrected to patient's body temperature using anaerobic temperature correction factors. Hemoglobin (Hb) was measured by the cyanmethemoglobin method. 1.34 ml of O_2/dl/g of Hb was used to calculate O_2 contents. $\dot{V}O_2$ was calculated by the Fick principle and the shunt was estimated with the standard shunt equation.

Results. No significant differences were measured between groups for most of the control variables but temperature and pHa in F_IO_2 = .5 and temperature only in F_IO_2 = .6. The changes produced by inhaling 100% O_2 are presented in the table. Significant changes in PaO_2, $Cc'O_2$ and CaO_2 were produced by breathing 100% O_2, as expected. While $P\bar{v}O_2$ increased significantly at F_IO_2 of .4, .5 and .6, $C\bar{v}O_2$ increased at F_IO_2 of .3, .5 and .6. There was a significant increase in shunt only at F_IO_2 of .3 and .4. The changes in shunt at F_IO = .3 were significantly different from the other 3 groups. The changes in the ratio PaO_2/F_IO_2 increased significantly at F_IO_2 of .4 and .5. Differences in the magnitude of changes between groups are given in the table. No significant changes in VO_2, Qt and a-v were observed in each group.

TABLE Changes produced by breathing 100% O_2. Measured and calculated values are expressed as a percent of controls (Mean ± S.D.). Five patients per group.

VARIABLE	F_IO_2 .3	.4	.5	.6
% Δ PaO_2	223 ± 51*	186 ± 15*o	194 ± 49*a	87 ± 59*a
% Δ $PaCO_2$	-3 ± 9	5 ± 6	4 ± 16o	7 ± 7
% Δ pH_a	.3 ± .2*	.1 ± .4	-.3 ± .4	.3 ± .3
% Δ $P_{\bar{v}}O_2$	30 ± 26	15 ± 12*	27 ± 16*	10 ± 5*ab
% Δ $P_{\bar{v}}CO_2$	1 ± 8	2 ± 5	7 ± 13	4. ± 7
% Δ $pH_{\bar{v}}$	.1 ± .4	.1 ± .5	.2 ± .3	-.2 ± .4
% Δ Qt	2 ± 9	1 ± 15	8 ± 11	6 ± 8
% Δ CCO_2	10.6 ± 1.3*	7.7 ± .5*	7.0 ± 1.2*	5.5 ± .8*
% Δ CaO_2	7.1 ± 1.9*	5.9 ± .4*o	6.6 ± 1.3*a	3.3 ± 1.9*a
% Δ C_aO_2	13.8 ± 9.0*	10.9 ± 14.1	15.2 ± 7.1*	7.3 ± 5.6*
% Δ VO_2	-9 ± 16	5 ± 36	-7 ± 20	1 ± 8a
% Δ Qs/Qt	243 ± 156*	72 ± 45*o	33 ± 43o	53 ± 51o
% Δ a-v	-9 ± 22	1 ± 23	-14 ± 18	-4 ± 6oa
% Δ PaO_2/F_IO_2	3 ± 15	14 ± 6*	47 ± 25*a	12 ± 35a

* significantly different from zero (paired t test, $p < .05$)
o significantly different from F_IO_2 = .3 ($p < .05$)
a significantly different from F_IO_2 = .4 ($p < .05$)
b significantly different from F_IO_2 = .5 ($p < .05$)

Discussion. The intrapulmonary shunt is estimated from 3 variables: $Cc'O_2$, CaO_2 and $C\bar{v}O_2$. Thus, the magnitude of the shunt will depend upon the corresponding values for each of the variables, regardless of the condition of the patient. Furthermore, with increases in F_IO_2, the 3 variables are expected to increase proportionally in order to maintain a constant shunt. This was not the case in the present study. While $Cc'O_2$ increased in a predictable manner according to F_IO_2 and Hb, CaO_2 and $C\bar{v}O_2$ did not (see figure). It is known that an increase in shunt will lower the CaO_2 and possible $C\bar{v}O_2$. Thus, the F_IO_2-induced shunt prevented a proportional rise in CaO_2 and $C\bar{v}O_2$. Changes in $C\bar{v}O_2$ were larger and unpredictable. Note that inspite of not significant changes in $\dot{V}O_2$ and a-v, and therefore in $\dot{Q}t$, the magnitude of the changes in these variables were significantly different between the groups, in particular a-v. Furthermore, the changes in a-v were correlated with the changes in $\dot{V}O_2$ ($r = .87$ $p < .001$). According to our theory (2), the F_IO_2-induced shunt may be due to changes in $Cc'O_2$, $\dot{Q}t$ or $\dot{V}O_2$, modulated by changes in $C\bar{v}O_2$. Since the present results showed predictable changes in $Cc'O_2$ and no change in $\dot{Q}t$, it became important to examine the relationship between the changes in $C\bar{v}O_2$ as a function of changes in $\dot{V}O_2$. We found an inverse relationship between these variables: the larger the changes in $C\bar{v}O_2$, the smaller the changes in $\dot{V}O_2$ ($r = .69$ $p < .001$). In conclusion, the present study support our hypothesis: the observed changes in shunt depend upon the concomitant changes in $\dot{V}O_2$, $\dot{Q}t$ and/or $C\bar{v}O_2$.

References

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