A260

TITLE: SUPPLY-DEPENDENT OXYGEN CONSUMPTION AND MIXED VENOUS OXYHEMOGLOBIN SATURATION DURING ISOVOLEMIC HEMODILUTION IN PIGS

AUTHOR: J. Räsänen, M.D.

AFFILIATION: Department of Anesthesiology, University of South Florida College of Medicine, Tampa, FL 32216

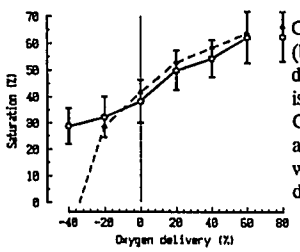
The utility of mixed venous oximetry during acute severe anemia depends on the responsiveness of mixed venous oxyhemoglobin saturation ($S\bar{v}O_2$) to a reduction in oxygen supply. If hemodilution decreases oxygen delivery ($\dot{D}O_2$) sufficiently to limit oxygen consumption ($\dot{V}O_2$), $S\bar{v}O_2$ may become insensitive to a further reduction in $\dot{D}O_2$. This study was designed to assess the responsiveness of mixed venous oximetry under conditions of supply-dependent $\dot{V}O_2$ secondary to normovolemic anemia.

Ten pigs weighing 20 to 30 kg were anesthetized with pentobarbital, tracheotomized, paralyzed with pancuronium, and mechanically ventilated. A carotid and the pulmonary artery were cannulated for pressure measurement and blood sampling. Additional arterial and venous catheters were inserted for rapid blood withdrawal and volume replacement.

After baseline measurements, gradual isovolemic hemodilution was induced by replacing 5 to 10 ml/kg blood with low molecular weight dextran until $\dot{V}O_2$ decreased by 20%. Ten minutes after each blood withdrawal, blood pressure, central venous pressure, and heart rate were recorded; arterial and mixed venous blood were sampled and analyzed for blood gas values, pH, oxyhemoglobin saturation, and hemoglobin concentration. Oxygen uptake was measured continuously using indirect calorimetry. Cardiac output was determined using the thermodilution technique with four 10 ml injections of iced normal saline. The critical $\dot{D}O_2$ was determined using the double-regression method. Slopes of $S\bar{v}O_2$ decline above and below critical $\dot{D}O_2$ were compared using Student's t-test for paired observations.

Supply-dependent $\dot{V}O_2$ was reached at an average hemoglobin concentration of 3.9±0.7 g/dl (mean±SD), an $S\bar{v}O_2$ of 38.2±8.1%, and an oxygen extraction ratio of 0.55±0.10. The change in $S\bar{v}O_2$ corresponding to a 100 ml decrease in $\dot{D}O_2$ was -9.2±3.7% when $\dot{D}O_2$ was supply-independent, and -7.6±5.2% when it was supply-dependent (NS). However, the rate of decline in $S\bar{v}O_2$ in the supply-dependent range was significantly slower than would be expected under conditions of independent oxygen supply and demand (-32.6±16.3%; $p<0.01$).

Supply-dependent $\dot{V}O_2$ has been shown to render $S\bar{v}O_2$ insensitive to changes in $\dot{D}O_2$, or even to reverse the usual relationship between $S\bar{v}O_2$ and $\dot{D}O_2$ in patients with sepsis or chronic tissue hypoxia without anemia. The current study shows that development of supply-dependency of $\dot{V}O_2$ secondary to isovolemic hemodilution does not compromise the usefulness of mixed venous oximetry in detecting further changes in $\dot{D}O_2$. Better capillary perfusion and cellular function may explain preservation of effective oxygen extraction during dilutional anemia compared with other clinical conditions, even at very low levels of $\dot{D}O_2$.



Observed (solid line) and expected (broken line) changes in $S\bar{v}O_2$ during a decrease in $\dot{D}O_2$ secondary to isovolemic hemodilution in pigs. Oxygen delivery is expressed in percent above and below a critical point below which $\dot{V}O_2$ becomes delivery-dependent.

A261

TITLE: RELATION BETWEEN RECOVERY ENERGY EXPENDITURE AND INTRAOPERATIVE HEAT BALANCE

AUTHORS: B.JUST MD, E.DELVA MD, Y.CAMUS MD, A.LIENHART MD

AFFILIATION: Dept Anesth., St-Antoine Hosp., Paris, France

Intraoperative hypothermia often results in postoperative shivering, which is associated with increased oxygen uptake ($\dot{V}O_2$).[1] However, the connection between the magnitude of recovery $\dot{V}O_2$ and the patients' temperature is not clear.[2] We thus studied the energy spent during recovery in relation to the intraoperative thermic state.

METHOD: After institutional approval and informed consent, 14 ASA class I-II adult patients undergoing elective abdominal surgery, lasting at least 3 hrs, were studied. Anesthesia was induced with flunitrazepam, fentanyl and pancuronium then maintained with N_2O in O_2 under mechanical ventilation and the same drugs, as required. Hypothermia was actively prevented in only 7 patients. Core and skin temperatures (T) were continuously recorded to calculate changes in total body heat content (ΔTBH, kJ), according to Ramanathan's [3] and Burton's [4] formulae. $\dot{V}O_2$ was measured preoperatively, as basal, then continuously during recovery (MMC Sensormedics®), and recovery energy expenditure was calculated as shown in fig 1. The occurrence of shivering and the peak of $\dot{V}O_2$ ($\dot{V}O_2max$) were recorded. Data (mean±SE) were compared by paired t-test and linear regression.

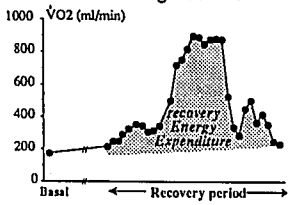


Figure 1: $\dot{V}O_2$ above basal was integrated over the recovery period to calculate recovery energy expenditure (EE, grey area, kJ), assuming an energy equivalence of 20.7 kJ per liter O_2.[1]

RESULTS: At the end of surgery, core T ranged from 33.4 to 37.8 °C. Intraoperative heat balance ranged from -627 to +301 kJ (fig 2). $\dot{V}O_2max$ (301 to 898 ml.min-1) was poorly correlated with core T (r=0.54), and not correlated with mean skin or mean body T (r=0.38 and 0.40, respectively). Recovery EE was highly correlated with core T at the end of surgery (r=0.90), with intraoperative ΔTBH (r=0.88; fig 2) and recovery ΔTBH (r=0.95; fig 3). Shivering occurred in five patients, at a core T ≤ 35°C: their recovery EE did not significantly differ from recovery ΔTBH and intraoperative ΔTBH.

DISCUSSION: This study confirmed the poor relation between postoperative $\dot{V}O_2max$ and intraoperative thermic state, even in hypothermic patients.[2] By contrast, the recovery energy expenditure was closely connected with the intraoperative heat loss. Besides, as evidenced by the equivalence of recovery EE and recovery heat gain, hypothermic patients spent as much energy during recovery as that required for postoperative spontaneous rewarming.

1.Circulation 68:1238-46,1983 2.Surgery 60:85-91,1966
3.J Appl Physiol 19:531-3,1964 4.J Nutr 9:261-80,1935