Title : ACUTE NORMOVOLEMIC HEMODILUTION

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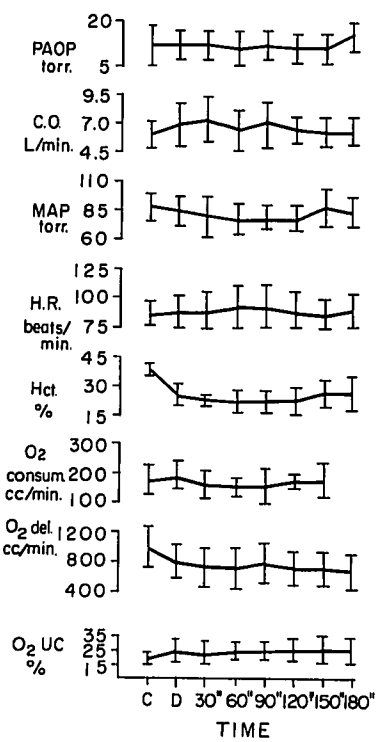
Acute normovolemic hemodilution is widely used during cardiac surgery to minimize the need for homologous blood transfusion and to reduce the incidence of serum hepatitis, transfusion reactions and other sequelae attributed to stored blood. Although the cardiopulmonary hemodynamics of chronic anemia have been studied, the consequences of acute hemodilution have not been well documented previously. Since we use hemodilution in selected cases of major cancer surgery, observations were made to supply this documentation.

Methods. Fifteen patients for whom hemodilution was chosen as part of their anesthetic management were observed during major abdominal surgery for malignancy. Their management included the isovolemic hemodilution technique currently in use at this hospital. The mean age was 60 years. Anesthesia was maintained with halothane-oxygen. Baseline measurements were made ten minutes after induction of anesthesia. Then, blood was withdrawn from a basilic vein catheter into standard CPD collection bags, which were then stored at room temperature. Simultaneously, an infusion of Ringer's lactate solution was begun in a ratio three parts to one of blood withdrawn. Blood withdrawal was continued until the hematocrit was between 20-25% then all measurements were repeated and surgery began. These measurements were made every 30 minutes throughout the operation. Intravascular blood volume as reflected by urine output, CVP, wedge pressure and blood pressure was maintained by crystalloid infusion, while blood was given to maintain the hematocrit at 20-25%. When all major bleeding had been controlled these infusions were stopped and the patient's own blood was reinfused at a rate commensurate with his cardiac filling pressures and clinical state. Furosemide, 0.5 mg/Kg was given intravenously if filling pressures were elevated and re-infusion was not complete. All patients were extubated in the operating room and observed in the surgical intensive care unit overnight.

Results. The mean CO increase was 16% after hemodilution and CO remained elevated throughout the procedure (see figure). MAP remained stable at approximately 85 torr. Heart rate did not change significantly, but stroke volume increased. Hemodilution caused a reduction in calculated total peripheral resistance (TPR) to approximately 80% of the control value. Wedge pressure was kept constant at 10-15 torr by the infusion of fluids. The mean arterial O_2 tension (FiO_2=1.0) was 380 ± 75 torr with a calculated intrapulmonary shunt of 23% at the start of the operation and 390 ± 10 torr with a shunt of 22% at the end of the procedure. With the patient awake, the pre and post anesthesia shunts were 13 ± 9% and 13 ± 8% respectively. With a reduction in hemoglobin there was a decrease in O_2 carrying capacity, but without an increase in the $Ca\text{-}vO_2$. O_2 consumption decreased 8%. Oxygen utilization coefficient (O_2UC), an index of the supply-demand ratio, remained in the normal range. An average of 3,000 ml of blood was withdrawn from each patient and the average amount of crystalloid infused was 10 liters.

Discussion. During acute normovolemic hemodilution the decrease in hematocrit and consequent decrease in O_2 carrying capacity are offset by an increase in CO, specifically stroke volume. $Ca\text{-}vO_2/CaO_2$, is a measure of the adequacy of O_2 delivery and remained stable. Intrapulmonary shunt was not affected by the large volumes of crystalloid used to maintain intravascular volume during operation. There were no abnormalities in electrolytes or clotting factors and no postoperative complications in any patient. This study shows that the major compensation for acute normovolemic hemodilution is an increase in CO coupled with a mild reduction in O_2 utilization under anesthesia. We found no adverse cardiac or pulmonary effects from hemodilution to a hematocrit of 20-25% with crystalloid volume replacement in patients anesthetized with halothane for colon surgery. The findings of this study should cause us to re-evaluate the dictum that a hematocrit of 30% is mandatory for elective surgery.

Cardiopulmonary Hemodynamics



C = control; D = after hemodilution; time in minutes