TITLE: EFFECT OF ANEMIA ON GAS EXCHANGE IN PULMONARY EDEMA

AUTHORS: M. J. Bishop, M.D., and F. W. Cheney, M.D.

AFFILIATION: Department of Anesthesiology, University of Washington School of Medicine, Seattle, Washington 98195

Introduction. Anemia is a common finding in patients with non-cardiogenic pulmonary edema, probably due to a combination of multiple organ failure and repeated withdrawal of samples for laboratory analysis. We used a dog model to assess the extent to which anemia affects gas exchange and lung function in the presence of pulmonary edema.

Methods. Twelve anesthetized and paralyzed dogs were studied during controlled ventilation one day after receiving 0.07-0.09 ml/kg of oleic acid, a procedure which produces a stable lung injury over the 4-hour time course used for the study. Animals underwent ligation of the splenic pedicle to prevent autotransfusion. Measurements of hemodynamics and arterial and pulmonary arterial blood gases were performed after splenic ligation, repeated after each step of a two-step isovolemic hemodilution, and again after retransfusion of the removed red cells. The first stage dilution was produced by the withdrawal of 17 cc/kg of blood and replacement with 17 cc/kg hetastarch. The procedure was then repeated with a 15 cc/kg phlebotomy and replacement. Finally, the withdrawn red cells were retrieved by centrifugation and reinfused after withdrawing the equivalent amount of whole blood from the animal. All measurements were made during both air and oxygen ventilation. O2 consumption was calculated from the Fick equivalent, O2 consumption = QL (CAO2 - CVO2).

Results. Control (C) hgb was 12.7 ± 2.4 gm/100 cc, decreasing to 9.1 ± 2.2 after the first dilution (D1) and 6.5 ± 2.0 after the second dilution (D2). Hgb rose to 10.1 ± 1.8 after retransfusion (T).

Venous admixture (Qva/Qt) measured during room air ventilation and shunt (Qs/Qt) measured during oxygen ventilation remained constant despite dilution and transfusion (Figure A). Oxygen delivery varied directly with hemoglobin (Figure B). PaO2 was stable during air ventilation but rose with dilution during oxygen ventilation from 277 ± 157 to 318 ± 175 torr (p < .05). Oxygen consumption did not correlate with oxygen delivery for oxygen delivery greater than 275 cc/minute, but did decline at lower levels of O2 delivery.

Discussion. Prior investigators have found oxygen delivery to be maintained in normals over a wide range of hgb, primarily because of increased QL. We found a direct relationship between the two, perhaps because of the lower PaO2 in our animals due to the lung injury. Hemodilution with hetastarch did not seem to affect Qva/Qt or Qs/Qt in the acute setting. We found that oxygen consumption was not altered by oxygen delivery in the range clinically encountered, in contrast to the human data reported by Danek et al.1 Although transfusion increases O2 delivery O2 consumption is not increased. On the basis of our results Hgb levels as low as 6.5 gm/l do not affect gas exchange in permeability pulmonary edema.

Supported by the American Lung Association and NIH grant HL-24163 and American Critical Care.

Reference.

Effect of dilution and transfusion on (A) gas exchange and (B) O2 delivery (D2). Closed circles represent values during 100% O2 ventilation, open circles during air ventilation. C = control, D1 = 17 cc/kg dilution, D2 = 15 cc/kg dilution, T = retransfusion.