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Title : PULMONARY CHANGES AFTER SEVERE NORMOVOLEMIC HEMODILUTION (NVHD) WITH LACTATED RINGERS (LR) VERSUS ALBUMIN IN DOGS

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Introduction. Choices of plasma substitutes for fluid resuscitation in massive hemorrhage need controlled comparative data with controlled hematocrit (hct). Acute NVHD to 10% hct with dextran 70, dextran 40 and hydroxyethyl starch in 1x replacement lead to survival in all dogs;[1] HD to 20% hct with LR in 2.5x replacement (once) could not support survival.[2] The above studies did not examine Alb, nor continued administration of LR to replace further losses. This study compared the effects of Alb and LR on the lungs during sustained severe NVHD to 10% hct.

Methods. Pilot experiments demonstrated that dogs tolerate human albumin without bronchospasm or hypotension. In 3 sham controls all operations and measurements were made without HD; none of the variables measured (see below) changed significantly over 4h, except for a spontaneous decrease in hct from about 40 to 30%.

Healthy mongrel dogs (10-15kg) received ketamine 15 mg/kg IM and intratracheal IPPV with N_2O/O_2 50%/50%, halothane 0.5% and pancuronium 0.1 mg/kg IV prn. TV was 10 ml/kg and f changed to maintain $PaCO_2$ ($PETCO_2$) at 30-35 torr. Cannulations for continuous monitoring were made for mean arterial pressure (abdominal aorta) (MAP), CVP, and pulmonary artery pressure (PAP, PAWP). Also continuously monitored were airway pressure (AP),T, urine flow (UF), and EKG. Intermittent determinations were made of serum osmolality, colloid osmotic pressure (COP) and albumin; hgb; hct; arterial and PA (or CV) blood gases and O_2 content; cardiac output (CO); and calculated pulmonary shunting ($\dot{Q}S/\dot{Q}T$), O_2 consumption ($\dot{V}O_2$), arterial O_2 transport (AOT), and $P(a-A)CO_2$. Maximal expiratory flow volume (MEFV) was measured during rapid deflation from TLC to a negative pressure of 30 cm H_2O, using pneumotachography.[3] Lung-thorax compliance was measured with a giant syringe and airway pressure gauge (inflation and deflation curves). Extravascular lung water (EVLW) was measured at sacrifice with the gravimetric technique, using hgb as a marker of pulmonary blood volume.[4]

For NVHD, hct was lowered to 10% over 90 min. by withdrawal every 10 min. of 10 ml/kg arterial blood, followed immediately by IV infusion of 1x human Alb 5% in isotonic saline, or 2.5x LR. Thereafter, 10% hct was maintained for 4h, which required no additional Alb; but additional LR to a total of 9x blood volume lost. All dogs were maintained on IPPV until sacrifice at 4h (or earlier death), except the 1 wk survivors which were weaned to spontaneous breathing after 4h.

The animals were divided into 3 groups: group I (n7), HD with Alb (2 dogs observed for 1 wk). Group II, HD with LR (n6). Group III, HD with LR (n6) plus sodium bicarbonate IV during and after HD to normalize pHa plus Alb at 4h to raise (5 dogs observed for 1 wk) serum albumin to 2.5 gm/dl.

Results. All 7 Alb dogs (group I) survived. All 6 LR dogs (group II) died at 2-4h after end of HD, with severe acidemia, tissue edema, ascites, and anuria (at normotension) followed by irreversible shock. There was no pulmonary edema. 5/6 LR dogs with bicarbonate (group III) survived 4h, 4/5 (after serum albumin) survived 1 wk without pulmonary edema. Tissue edema resolved. Increase in CO was sustained with Alb, not with LR. All variables not mentioned remained normal. $\dot{Q}S/\dot{Q}T$ was 10-20% throughout without difference between groups. There were only subtle changes at 2h of HD with LR, (not with Alb): $P(a-A)CO_2$ increased ($p<0.01$). Compliance and MEFV decreased slightly ($p<0.05$). EVLW was 78.0% of total lung weight in the sham operated controls, 77.1 with LR-HD and 74.4 with Alb-HD. (no diff.).

COP and serum Alb remained unchanged with Alb-HD. With LR, COP decreased to 2.5 torr and Alb to 1.1 g/dl. pHa remained above 7.2 with Alb-HD, but decreased to 6.9-7.0 with LR-HD. pHa normalization required bicarbonate 6 mEq/kg over 4h.

Conclusions. NVHD to 10% hct during IPPV with Alb is superior to LR. Neither provokes pulmonary edema. LR however, lost into tissue edema and ascites cannot support life without added colloid. pHa control increases the tolerance of NVHD with LR.

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