Continuous Noninvasive Hemoglobin: Impact of Hemorrhage on Volume Expansion of Crystalloid in Humans.

Kinsky M., Salter M., Daneshvari S., Indrikovs A., Kramer G. *Proceedings of the 2010 Annual Meeting of the American Society Anesthesiologists.* Abs A391.

Background

The goal of Intravenous fluid replacement is to restore lost vascular volume. However, vascular volume expansion after crystalloid therapy is limited by the rapid distribution of infused fluid throughout the extracellular compartment. Hemorrhage induces potent compensatory mechanisms for auto transfusion, which can augment volume expansion during fluid therapy. The rapidity and effectiveness of auto transfusion remains the subject of debate. Objectives: (1) Compare the vascular volume expansion properties of a crystalloid fluid bolus in normovolemia and hemorrhage. (2) Determine if non-invasive hemoglobin can be used to predict vascular volume expansion.

Methods

IRB consent was obtained in ASA 1 healthy volunteers (age 21-35 yr). We measured volume expansion in normovolemic human volunteers (n=5) after a 25 ml/kg - 20 min infusion of lactated Ringer's. In a second group of volunteers (n=4), subjects underwent general anesthesia and then simultaneously bled 10ml/kg and infused 30 ml/kg - 20 min of LR. Hemodynamic variables were measured, arterial pressure via catheter-transducer and cardiac output via echocardiography. Blood hemoglobin, measured by CO-Oximeter (Co-Ox), was compared to noninvasive Masimo Rainbow SET SpHb. Baseline blood, plasma and red cells volumes (BV, PV, RBCV) were calculated using indocyanine green indicator dilution and hematocrit. The time course of PV was calculated from changes in hematocrit and changes in RBCV due to bleeding. Volume expansion efficiency was calculated as ([start_en]0394;PV + bled plasma) divided by infused volume. Measurements were recorded for 120 min (T120). Graphs show mean ± SEM.

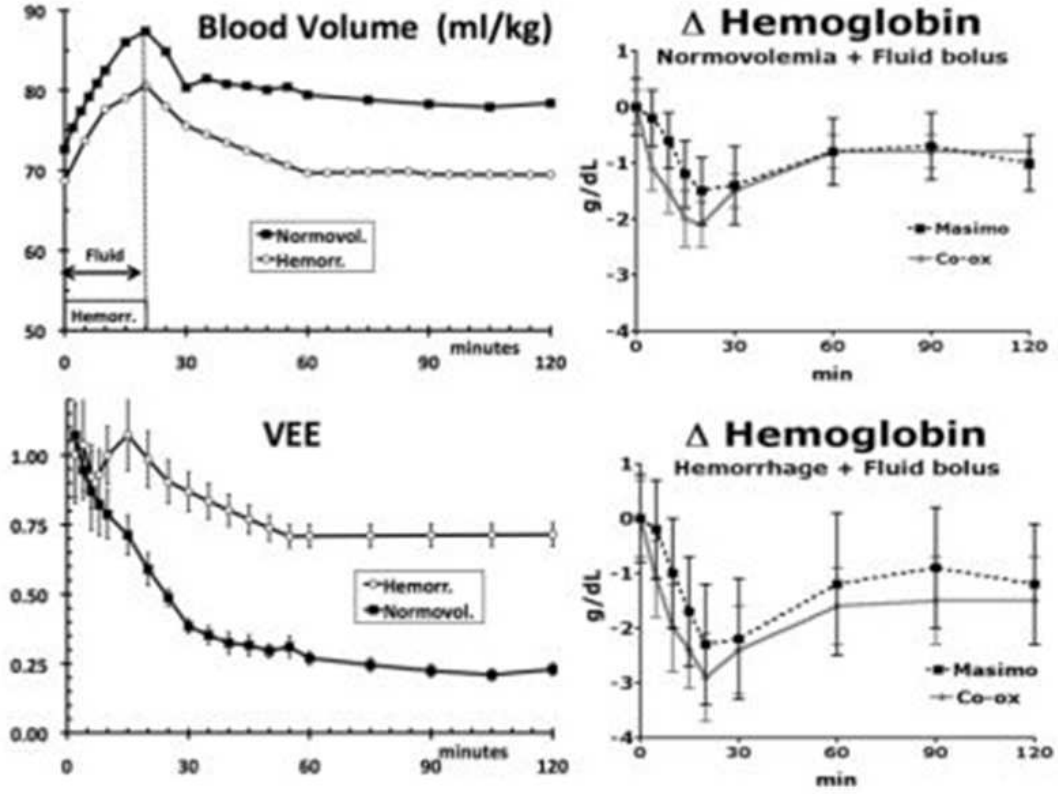
Results

Heart rate and arterial blood pressure did not change ($p > 0.05$) in either group after fluid bolus. A small increase in cardiac output and decrease in systemic vascular resistance ($p<0.05$) following fluid bolus was observed in both groups. Hemoglobin decreased after fluid loading. Hemorrhage resulted in larger decrease in hemoglobin ($p<0.002$- based on AUC analysis).The 3:1 infusion of LR during a 10 ml/kg hemorrhage enhanced vascular volume efficiency and resulted in a period of hypervolemia for 40 minutes post infusion and normovolemia thereafter. A strong correlation (r2=[start_en]003E;0.6) and low bias (-0.9 g/dL) of hemoglobin measured by Co-ox and SpHb was observed.

Conclusion

These data suggest that for small hemorrhages adequate volume replacement is achieved using less than the 3:1 rule suggests. The interactions between infused volume and autotransfusion during larger hemorrhages remains to be defined. Masimo's SpHb provides an effective, novel, non-invasive indicator of vascular volume expansion. SpHb monitoring could help guide fluid resuscitation during hemorrhage.

Figure 1


Blood Volume (ml/kg)
Normovol.
Hemorr.
Fluid
Hemorr.
minutes
Δ Hemoglobin
Normovolemia + Fluid bolus
g/dL
Masimo
Co-ox
min
VEE
Hemorr.
Normovol.
minutes
Δ Hemoglobin
Hemorrhage + Fluid bolus
g/dL
Masimo
Co-ox
min