Comparison of Lactated Ringer’s and Hextend resuscitation on hemodynamics and coagulation following femur injury and severe hemorrhage in pigs

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Discussion Points:

This study used an animal model as follows: “Pigs were randomized into sham control (n = 7 each), LR, and Hextend groups. Femur fracture was induced using the captive bolt stunner at midshaft of the pigs’ left legs, followed by hemorrhage of 60% estimated total blood volume and resuscitation with either Hextend (equal to bled volume) or LR to reach the same mean arterial pressure. Pigs in the control group were not bled or resuscitated. Hemodynamics was monitored hourly for 6 hours. Coagulation, blood gas, and blood chemistry were assessed at baseline, after injury and hemorrhage, and 15 min, 3h and 6h after resuscitation.”

The authors’ conclusions were: “After traumatic hemorrhage, coagulation function was restored within 6 hours with LR resuscitation but not with Hextend. The lack of recovery after Hextend is likely caused by greater hemodilution and possible effects of starches on coagulation substrates and further documents the need to restrict the use of high-molecular-weight starch in resuscitation fluids for bleeding casualties.”

Hextend was used as one of the arms of the study, making it more applicable to TCCC than the recent JAMA study, which included a variety of hetastarches.

The 6-hour study period is also very relevant for military operations, in which prolonged evacuation times are always a possibility.

All 21 of the animals in the study survived to the end of the observation period, despite the 60% blood loss.
The animals resuscitated with LR (118 ± 3 ml/kg) took almost 3 times as much fluid to maintain their hemodynamic status as the Hextend animals (42ml/kg), reinforcing the point that Hextend achieves equal volume expansion with much less carriage weight for combat medics, corpsmen, and PJs.

The lactate levels for the LR animals at the end of the 6-hour period were twice as high as for the Hextend animals, indicating that resuscitation was more effective with Hextend.

Hextend provided more effective restoration of intravascular volume than LR, as noted by greater hemodilution of red blood cells, hemoglobin, total protein, platelets, fibrinogen, and coagulation factors.

This was a controlled hemorrhage bleeding model, so it is not unexpected that, despite the decrease in coagulation function seen in the Hextend animals, survival was the same for both groups. Coagulopathy is less of a problem if the patient is not actively bleeding.

The animals in the Hextend group were bled 60% of their blood volume and the shed blood was replaced with equal volumes of Hextend. This would be equivalent to treating severe shock from extremity hemorrhage with 3 liters of Hextend, rather than the 500/500 mL hypotensive resuscitation strategy currently recommended.

The observation above raises the question of whether or not the treatment of shock should be different for uncontrolled vs controlled hemorrhage, as has been recommended in the past. Are we under-resuscitating shock from controlled hemorrhage by using only 1000 mL of Hextend?

The study also provides good evidence that Hextend maintains its initial volume expansion for at least 6 hours, making additional fluid administration unnecessary for casualties who have controlled hemorrhage.

Considerations for Further Research

There are two follow-on studies that come immediately to mind:

1) Comparing control, LR, and Hextend in a severe model of uncontrolled hemorrhage. An arm should be added for the smaller dose of Hextend
currently recommended by TCCC to study the effect of hypotensive resuscitation in the setting of uncontrolled hemorrhage.

2) Comparing control, LR, and Hextend in the same model as above, but adding an arm for the smaller dose of Hextend currently recommended by TCCC to study the effect of hypotensive resuscitation in the setting of controlled hemorrhage.

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