Hextend and 7.5% Hypertonic Saline with Dextran are Equivalent to Lactated Ringer's in a Swine Model of Initial Resuscitation of Uncontrolled Hemorrhagic Shock

Riha GM, Anderson R, Kunio NR, Van PY, Hamilton GJ, Differding JA, Schreiber MA

Introduction

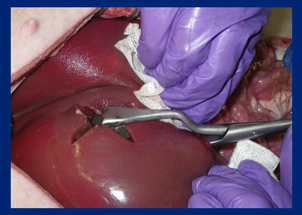
The current protocol in the United States military is to utilize a palpable radial pulse and normal mentation as pertinent endpoints to either start or stop fluid resuscitation.[1] Management guidelines for the initial fluid resuscitation of injured trauma patients were established by the Eastern Association for the Surgery of Trauma (EAST) after an extensive evidence-based review of the literature. These authors concluded that, similar to military protocol, in patients with penetrating injury and short transport times, fluids should be withheld for patients with a palpable radial pulse or alert mental status until patients reach definitive care. If fluid is to be given, the consensus group noted that there was insufficient evidence to recommend one type of fluid over another, and furthermore, the authors noted that small volume (250 ml) boluses of hypertonic solutions seemed equivalent with respect to hemodynamic parameters and volume expansion compared to larger volume (1000 ml) boluses of more standard solutions such as LR or NS. [2]

Objective

To determine the efficacy of an initial bolus of resuscitative fluids currently utilized in military and civilian settings on the physiologic response to uncontrolled hemorrhagic shock

Methods

Design: Prospective, randomized, blinded animal study
Setting: Level 1 Trauma Center animal laboratory
Participants: Fifty Yorkshire-crossbred female swine
Procedure: Anesthetized, mechanically ventilated swine received
- Central venous and arterial catheterization
- Standardized Grade V liver injury
- 30 minute uncontrolled hemorrhage
- After 30 minutes:
  - Liver packed
  - Randomized to 1 of 4 fluids or no fluids (NF)
    - -2 Liters of Normal Saline (NS)
    - -2 Liters Lactated Ringers (LR)
    - -500 ml Hextend (HEX)
    - -250 ml 7.5% Hypertonic Saline with 3% Dextran (HTS)
- 12 minute blinded fluid resuscitation
- Continuous MAP and StO2 monitoring
- Lab data collected at baseline, 1 hour, and 2 hours



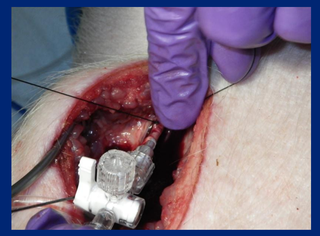
Grade V Liver Laceration

Randomized Fluid Resuscitation

Outcomes

Total blood loss after initial hemorrhage
StO_2 (tissue oxygenation monitoring)
Mean Arterial Pressure (MAP)
Labs were collected at Baseline, 1 hour, and 2 hours
Secondary blood loss measured at 2 hours or death

StO2 Monitor



Arterial Pressure Monitor

Results

Baseline characteristics of swine for all groups were similar
All animals had similar liver injuries (post-mortem autopsy)

Table1: Primary Blood Loss

Fluid	Primary blood loss	Survival
NS	1063.9 ± 103.9	10
LR	794.6 ± 82.3	10
HEX	870.5 ± 103.3	10
HTS	981.4 ± 126.5	10
NF	956.2 ± 139.9	8

No significant differences between groups

Table 2: Secondary Blood Loss

Fluid	Secondary blood loss
NS	138.5 (83.1, 169.6)
LR	127.5 (118.5, 134.5)
HEX	92.0 (77.4, 190.5)
HTS	99.1 (82.6, 145)
NF	**62.3 (37.3, 80.1)[a]**

Median with IQR, p ≤ 0.05; a = sig < NS, LR, HEX and HTS

Figure 1: Mean Arterial Pressure

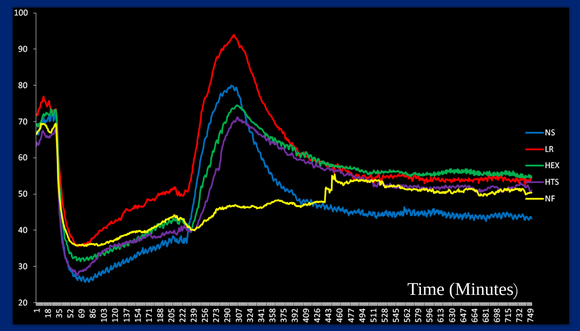


Table 3: Mean Arterial Pressure

Fluid	Baseline	1 hour	2 hour
NS	68.5 ± 4.4	**50.1 ± 2.9[a]**	43.3 ± 2.7[b]
LR	73.2 ± 4.5	63.3 ± 4.4	54.5 ± 3.4
HEX	70.7 ± 4.1	62.8 ± 2.1	54.6 ± 2.5
HTS	69.0 ± 2.9	60.0 ± 3.0	51.1 ± 2.2
NF	71.4 ± 3.3	**47.5 ± 4.8[a]**	46.6 ± 5.3

Mean ± SEM, p ≤ 0.05,
a = sig < LR, HEX, HTS ; b = sig < LR, HEX, HTS

Figure 2: StO2

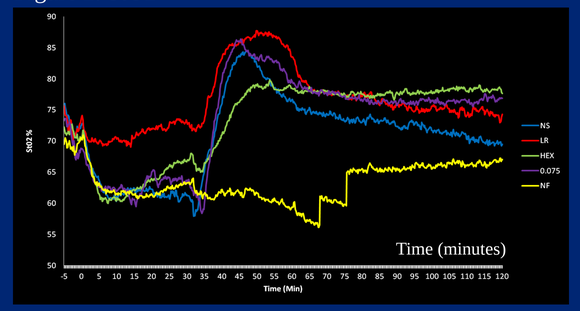


Table 4: StO2

Fluid	Baseline	1 hour	2 hour
NS	76.3 ± 2.7	76.8 ± 3.7	69.7 ± 2.5[c]
LR	75.8 ± 2.1	83.7 ± 2.1	74.5 ± 2.1
HEX	72.4 ± 1.6	78.5 ± 3.2	77.8 ± 3.4
HTS	73.6 ± 1.7	79.9 ± 1.0	77.1 ± 1.6
NF	69.7 ± 3.6	**59.6 ± 5.6[a]**	67.3 ± 3.2[b]

Mean ± SEM, p ≤ 0.05,
a = sig < NS, LR, HEX, HTS; b = sig < LR, HEX, HTS; c = sig < HTS

Table 5: pH

Fluid	Baseline	1 hour	2 hour
NS	7.54 (7.48, 7.59)	7.43 (7.36, 7.49)	**7.43 (7.35, 7.51)[a]**
LR	7.54 (7.51, 7.58)	7.47 (7.42, 7.53)	7.54 (7.49, 7.57)
HEX	7.56 (7.53, 7.58)	7.51 (7.42, 7.56)	7.57 (7.50, 7.60)
HTS	7.53 (7.46, 7.59)	7.44 (7.36, 7.48)	7.48 (7.37, 7.53)[b]
NF	7.56 (7.50, 7.58)	7.49 (7.42, 7.53)	7.52 (7.50, 7.54)

Median with IQR, p ≤ 0.05
a = sig < LR, HEX, NF; b = sig < LR, HEX

Conclusions

Withholding resuscitative fluid results in the least amount of post-treatment blood loss

In the clinically utilized bolus volumes given, HEX, HTS and LR are similar with respect to studied physiologic parameters

HEX, HTS and LR resulted in increased MAP and increased StO_2 compared to NF

NS provided a similar outcome compared to the NF group but resulted in a more acidotic state and increased secondary blood loss

References

1. Holcomb JB. Fluid resuscitation in modern combat casualty care: Lessons learned from somalia. *Journal of Trauma-Injury Infection & Critical Care*. 2003;54(5 Suppl):S46-51.
2.Cotton BA, Jerome R, Collier BR, et al. Guidelines for prehospital fluid resuscitation in the injured patient. *Journal of Trauma-Injury Infection & Critical Care*. 2009;67(2):389-402.