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Resuscitation from Hypothermic Hemorrhagic Shock Model with Hemoglobin-based Oxygen Carriers and Conventional Resuscitation Fluids

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The development of hypothermia in trauma patients is considered a significant risk factor for increased complications and mortality. However, hypothermia commonly arises in the prehospital environment from injury, anesthesia, ambient temperature, and administration of cold fluids. In this setting, management of hemorrhage becomes increasingly difficult, as hypothermia contributes to greater transfusion requirements, which can exacerbate trauma-induced coagulopathy. Given the critical need for resuscitative fluids that remain effective under these conditions, the objective of this study was to determine the efficacy of the existing resuscitative solutions including packed red blood cells (pRBCs) and fresh plasma (FP), and a hemoglobin-based oxygen carrier (HBOC) during a hypothermic hypovolemic shock. HBOCs are of particular interest in this study because of their robust storage stability and oxygen-carrying capacity, which may offer logistical advantages in austere environments. To evaluate the efficacy of these resuscitation solutions under a hypothermic hemorrhagic shock, anesthetized Sprague-Dawley rats were instrumented with a right femoral artery and right femoral vein catheter for hemodynamic assessment, and blood withdrawal and intravenous infusion, respectively. A rectal thermometer was used to measure the animal's core body temperature. After baseline measurements, the animals were placed on an ice pack until their internal temperature reached 34.5°C. The animals were then hemorrhaged for 40% of their blood volume (estimated as 7% of their body weight) and resuscitated with 25% of their blood volume with either FP, pRBCs, or HBOC. Shock was monitored for 45 minutes while resuscitation was monitored for 1 hour. Systemic variables were characterized as mean arterial pressure (MAP), heart rate (HR), and blood chemistry. Organs were harvested at the end of the experimental protocol for biomarker analysis. Across all animals, the baseline mean arterial pressure (MAP) and heart rate (HR) averaged 85 ± 6 mmHg and 372 ± 36 beats per minute (BPM), respectively. During shock, these values decreased to 42 ± 9 mmHg and 266 ± 38 BPM. Resuscitation with pRBCs, FP or HBOC, resulted in increases of 56%, 54%, and 24% in MAP, respectively, 60 minutes after shock. There were no statistically significant differences in MAP between baseline and resuscitative timepoints regardless of resuscitative solution. However, both the FP and HBOC group had statistically significant differences in HR from baseline following resuscitation. All groups demonstrated a statistically significant increase in the plasma

measurement of interleukin (IL)-6, IL-10, chemokine CXCL-1, and tumor necrosis factor alpha (TNF- α) and kidney measurement of IL-6, IL-10, and CXCL1 compared to controls. Resuscitation with pRBCs resulted in significantly greater kidney inflammation compared to either FP or HBOC. In plasma measurement of troponin, only the pRBC and HBOC groups demonstrated a statistically significant increase compared to controls. These findings highlight the potential of HBOCs as a viable alternative to traditional resuscitative fluids, particularly in the setting of hypothermic hemorrhagic shock. Although pRBCs and FP demonstrated improvements in MAP, the HBOC demonstrated suitable stabilization in systemic parameters. Considering HBOCs offer the logistic advantage of reduced storage requirements compared to conventional blood products, these results demonstrate the renewed potential of HBOCs for prehospital trauma care.

This abstract was presented at the American Physiology Summit 2026 and is only available in HTML format. There is no downloadable file or PDF version.