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Comparison of Commercial Fluid Warmers for Extreme Cold Field Transfusion

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Introduction

Early blood transfusion is vital for the care and resuscitation of hemorrhage sustained in combat and often occurs enroute to a higher level of care. In an arctic combat environment, hypothermia becomes a concomitant complication to hemorrhage, which can be compounded by rapid transfusion of cold whole blood. The use of a commercial fluid warmer for warming blood could improve outcomes in arctic combat resuscitation.

Objectives

Objective 1: Characterize the impact transfusing cold stored (1-6°C) whole blood on thermoregulation in large swine.

Objective 2: Characterize the impact transfusing cold stored (1-6°C) whole blood using a blood warming device on thermoregulation in large swine.

Methods

Swine (N=16, 40–50 kg) were acclimated for 5 days prior to experimentation. The night prior to experimentation swine were fasted and provided water ad lib. On the day of experimentation anesthesia was induced with ketamine and isoflurane via nose cone, then the animal was intubated, and instrumented for hemodynamic monitoring and blood collection. Core temperature was monitored via esophageal and rectal temperature probes.

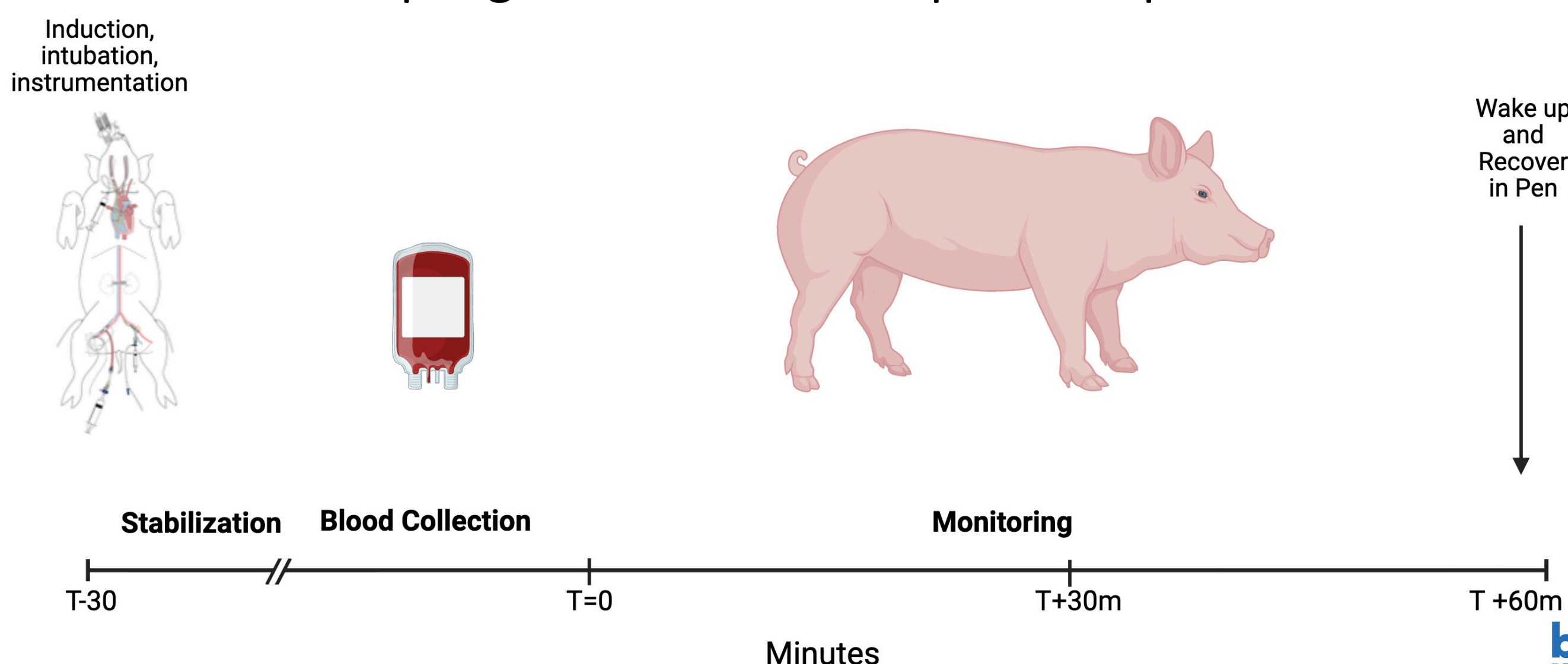


Figure 1. Experimental Phase 1 Blood Collection: One unit of blood was collected from each study animal and stored at 4°C until transfused. Following blood collection animals were recovered from anesthesia and extubated.

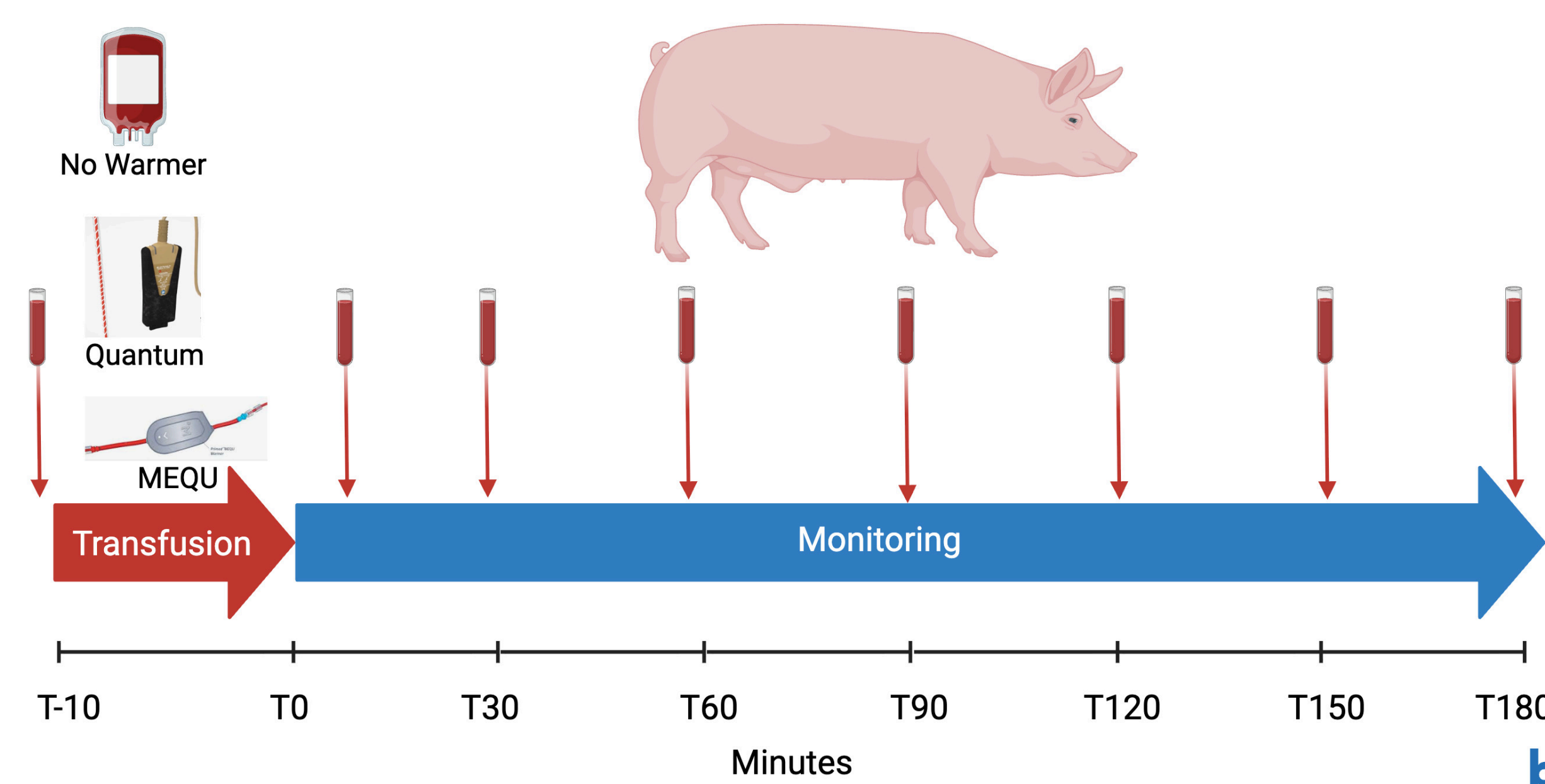


Figure 2: Experimental Phase 2 Blood Transfusion: Timeline of blood transfusion in a swine model. One unit of whole blood was transfused using no warmer (n=6), the MEQU warmer (n = 5), or the Quantum warmer (n = 5) and blood samples collected at predefined timepoints.

Methods

Outcomes: The primary outcome was core body temperature change. Secondary outcomes included hemodynamics, blood chemistry, thromboelastogram (TEG) reaction time (R time) and maximum amplitude (MA), oxygen saturation, and blood gases.

Results

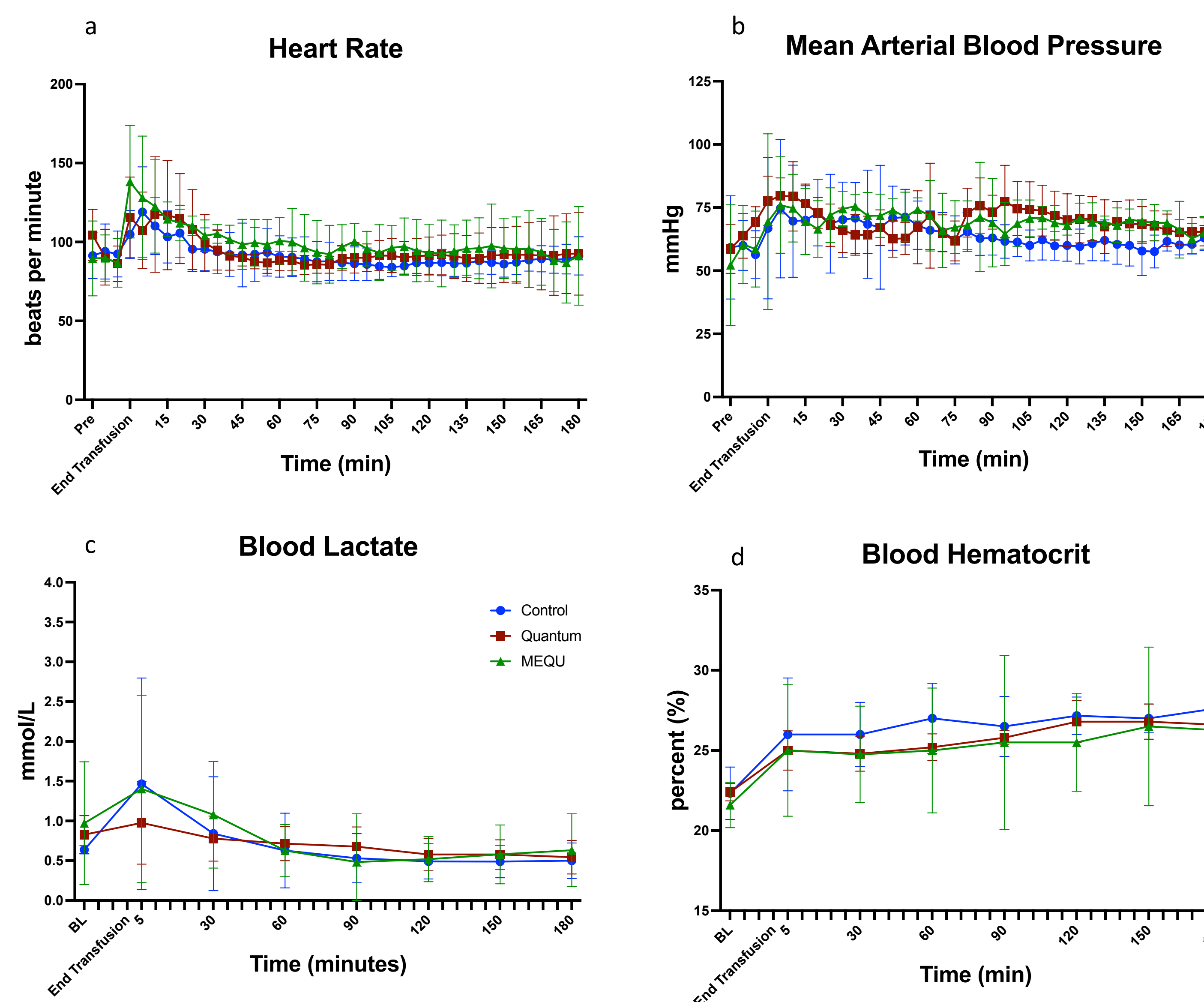
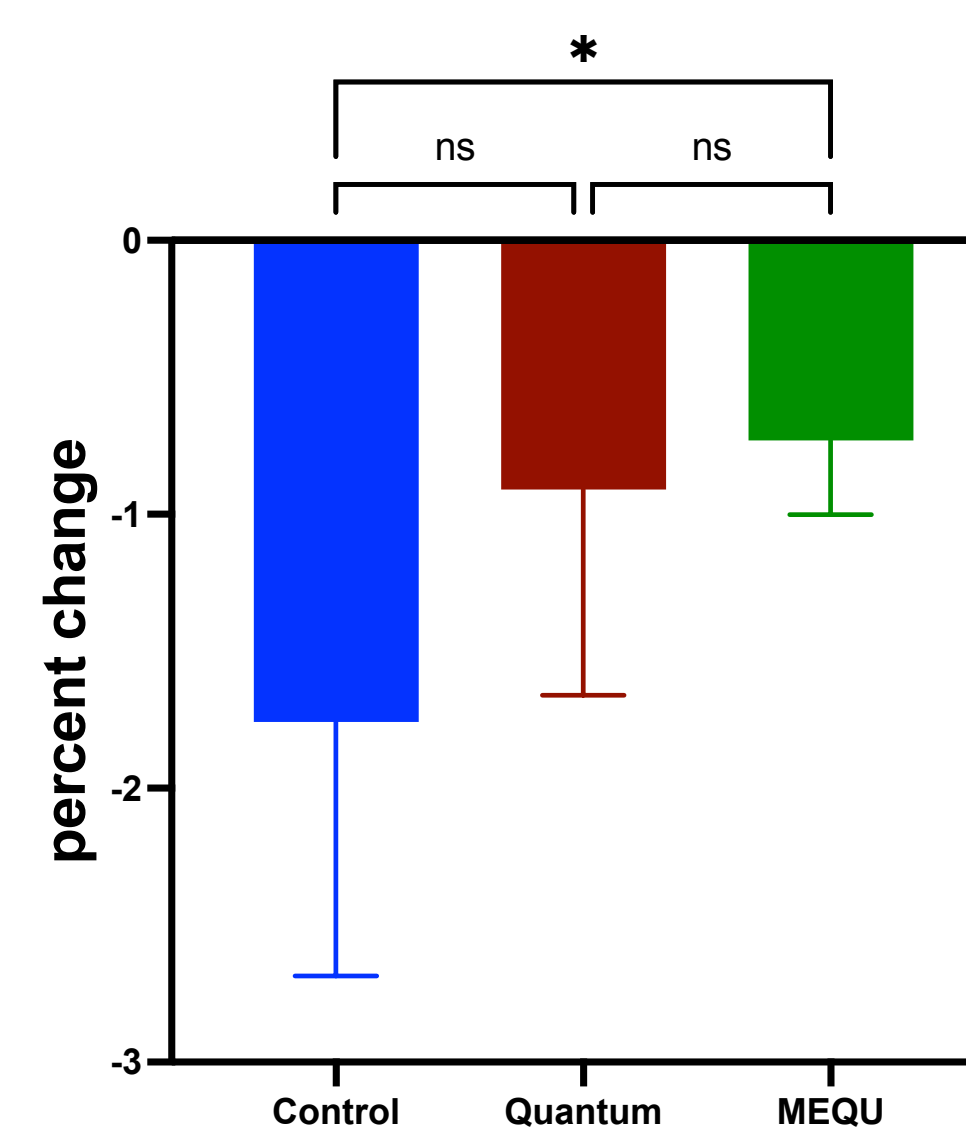


Figure 3. Physiological and Laboratory Assessment: There were no statistically significant changes in (a) heart rate, (b) mean arterial blood pressure, (c) blood lactate, or (d) hematocrit during the phase II transfusion experiment.

Percent Change in Core Body Temperature at the End of Transfusion (Esophageal Temperature Probe)



Percent Change in Core Body Temperature at the End of Transfusion (Rectal Temperature Probe)

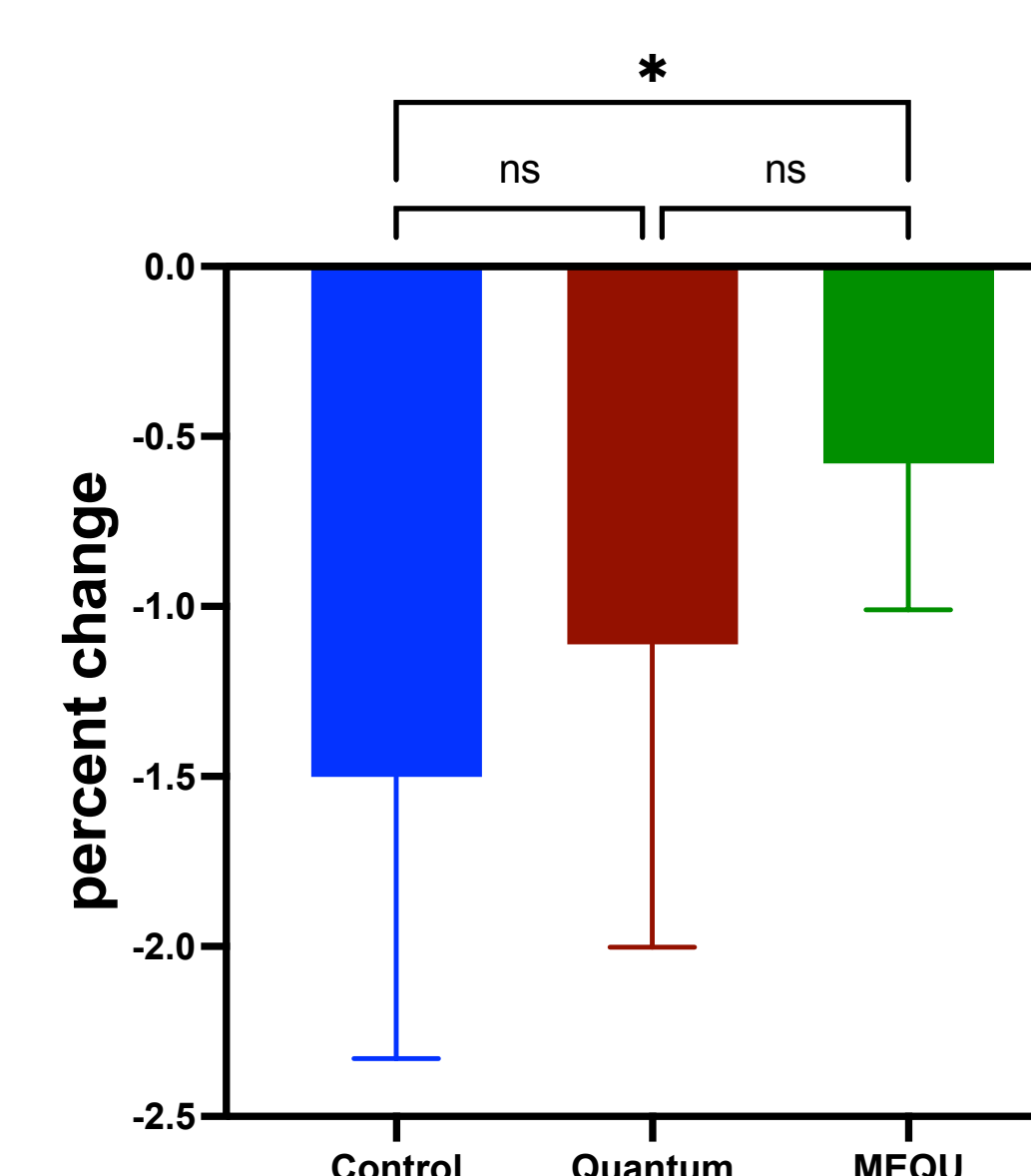


Figure 4. Percent Core Body Temperature at End of Transfusion: Swine in the control group showed the greatest drop in core body temperature immediately following completion of the blood transfusion compared to swine in the Quantum and MEQU blood warmer groups. The MEQU blood warmer group showed a statistically significant reduction in hypothermia compared to the no blood warmer control group.

Results

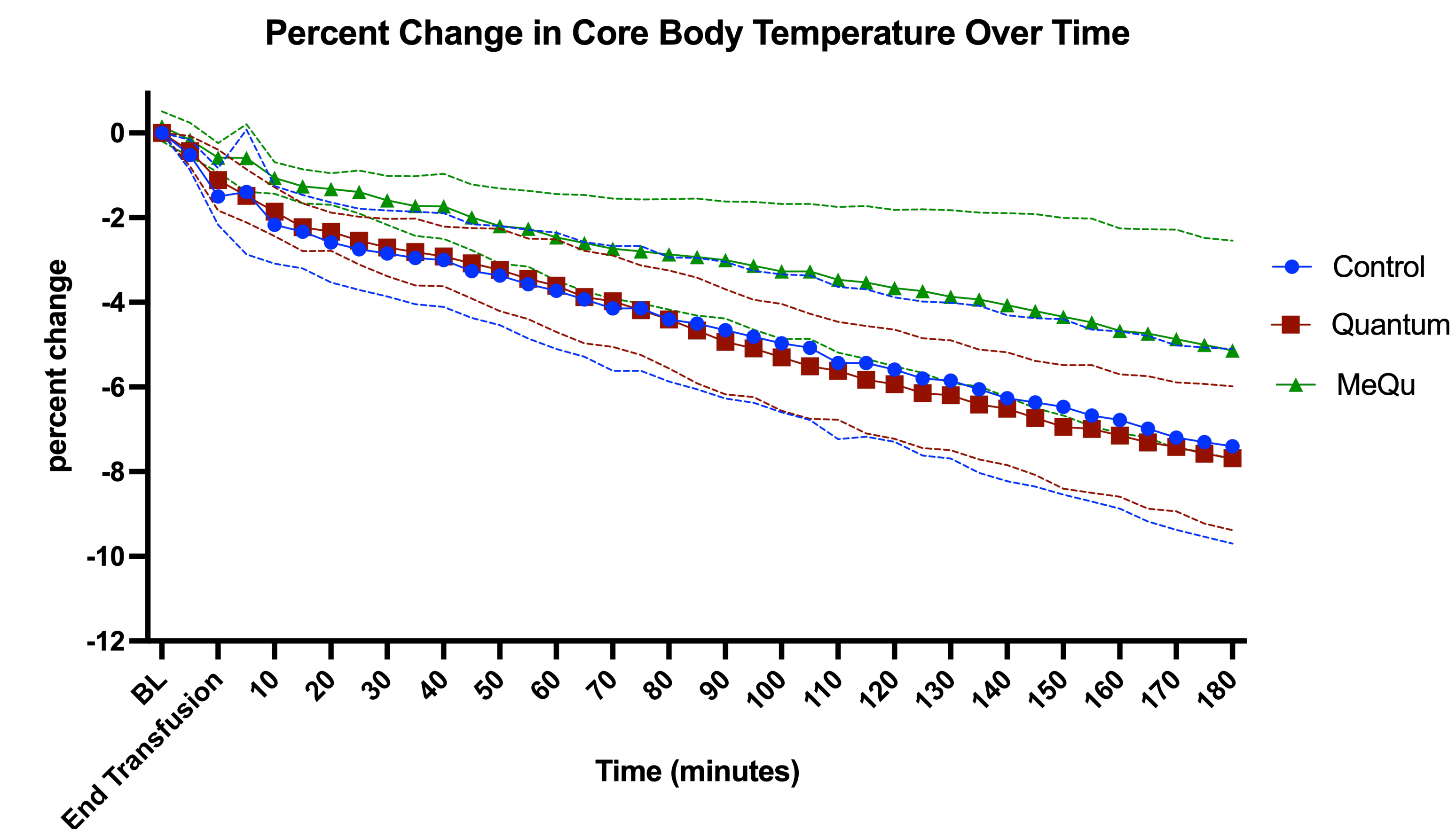


Figure 5. Percent change in core body temperature over time (Rectal temp). Core body temperature was monitored for 180 minutes after the end of transfusion. Swine in the MEQU blood warming device group showed reduced hypothermia compared to the Quantum and control groups immediately following the transfusion. By the end of the transfusion there was no statistical difference between groups. The solid line represents the sample mean and the dashed lines represent $\pm$ standard deviation.

Conclusion

- Warming cold stored blood during transfusion can reduce post transfusion hypothermia immediately after transfusion.
- There were no adverse physiological effects from warming cold stored blood detected up to 3 hours post transfusion.
- The MEQU blood warming device significantly reduced hypothermia in this study immediately after transfusion compared to the no intervention control; however additional heating adjuncts such as warming blankets are needed to prevent long term hypothermia.

Future Directions

- Evaluate the efficacy and outcomes of warming cold stored whole blood in the swine model of trauma and hemorrhagic shock with and without traumatic brain injury.

Disclaimer

The views expressed in this poster are those of the authors and do not necessarily reflect the official policy or position of the Defense Health Agency, Department of Defense, nor the U.S. Government. This work was supported by funding from the DHA FY23 RESTORAL Program. The study protocol was approved by the University of Colorado Institutional Animal Care and Use Committee (IACUC) and reviewed by the AFOSR in compliance with all applicable Federal regulations governing the protection of animal subjects. The experiments reported herein were conducted in compliance with the Animal Welfare Act and per the principles set forth in the "Guide for the Care and Use of Laboratory Animals, Eighth Edition", The National Academies Press, 2011. Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government.