The Effect of Mild Hypobaric Hypoxia on Splenic Erythroid and Myeloid Cells After Muscle Trauma-Hemorrhage

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Background

Intercontinental aeromedical transport is a key intervention for soldiers wounded on the battlefield. However, during transport, certain soldiers may not receive supplemental oxygen and/or the aircraft cabin pressure may affect tissue oxygenation, especially for soldiers sustaining trauma-hemorrhage. In our study, we investigated the effect of exposure to mild hypobaric hypoxia (HB), which represents the oxygen status of the aircraft cabin, on splenic erythropoiesis and inflammation after muscle trauma-hemorrhage.

Methods

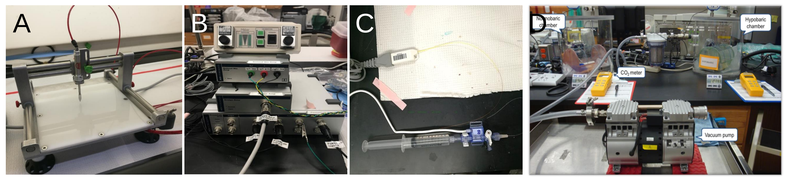

Figure 1. **Experimental Setup and Design.** (A) Crush Muscle Trauma Setup, (B,C) Hemorrhagic Shock + Fluid Resuscitation Setup, and (D) Flight/Transport Setup.

Table 1**. C57BL/6 Mouse Groups (*n* = 5–20)**

Group	CMT	HS	Flight	Group	CMT	HS	Flight
Co-NB	No	No	No	Co-HB	No	No	✓
Sm-NB	✓	No	No	Sm-HB	✓	No	✓
Sk-NB	✓	✓	No	Sk-HB	✓	✓	✓

Abbreviations: CMT = Crush muscle trauma; HS = hemorrhagic shock; MAP = mean arterial pressure; EU = euthanasia; NB = normobaric normoxia; HB = hypobaric hypoxia; Co = control (no CMT or HS); Sm = sham shock (CMT plus sham HS); and Sk = shock (CMT plus HS); RBC = red blood cells; RelSW = relative spleen weight; ImRets = immature reticulocytes. *Statistical analysis was performed using the Kruskal-Wallis chi-square test with Bonferroni adjustments. $p < .05$

These animal procedures were approved by the University of Nevada, Las Vegas Institutional Animal Care and Use Committee and the U.S. Army Research Center and Materiel Command Animal Care and Use Review Office.

Methods and Results

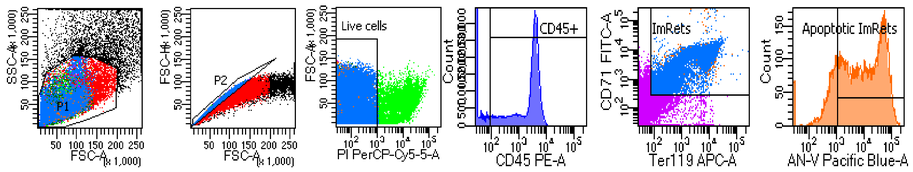

Figure 2. **Flow Cytometry Gating Strategy to Identify Splenic CD45/CD71/Ter119 ImRets and Apoptotic ImRets.**

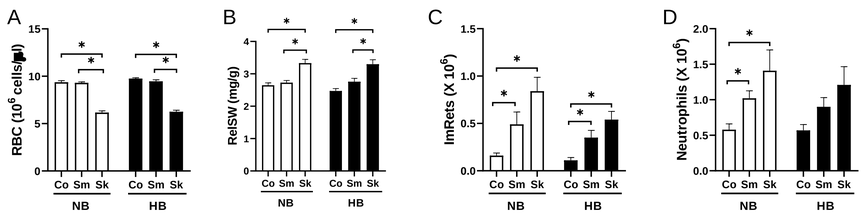

Figure 3. **Immediately Postflight.** In both Sk groups, the circulating RBC count is decreased (A), and RelSW (B) and splenic ImRets number (C) are increased. However, an elevated neutrophil count is detected only in Sk-NB (D).

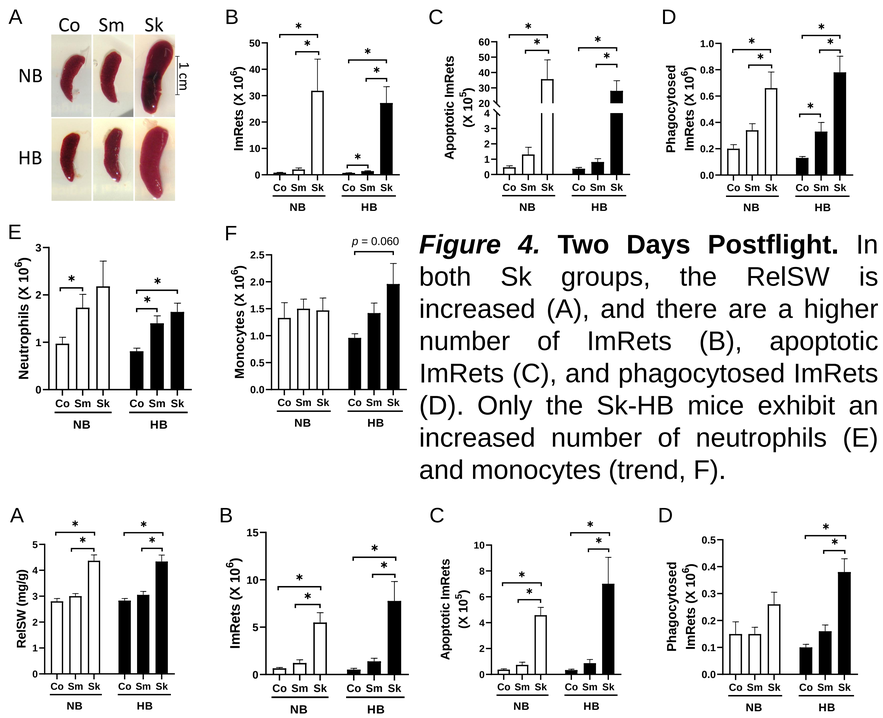

Figure 4. **Two Days Postflight.** In both Sk groups, the RelSW is increased (A), and there are a higher number of ImRets (B), apoptotic ImRets (C), and phagocytosed ImRets (D). Only the Sk-HB mice exhibit an increased number of neutrophils (E) and monocytes (trend, F).

Figure 5. **Six Days Postflight – Splenic Erythroid Cells.** In both Sk groups, the RelSW is increased (A) and there is a greater number of ImRets (B) and apoptotic ImRets (C). Only the Sk-HB mice exhibit an increased number of phagocytosed ImRets (D).

Results

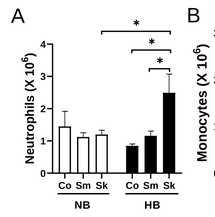

Figure 6. **Six Days Postflight – Splenic Myeloid Cells.** Only the Sk-HB mice exhibit an increased number of neutrophils (A) and monocytes (B).

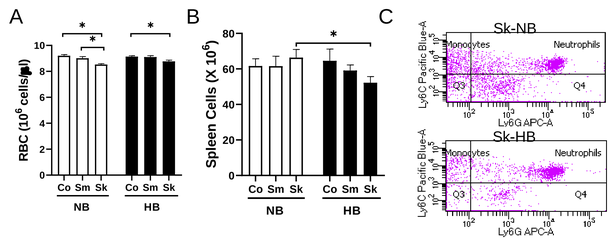

Figure 7. **Twelve Days Postflight.** The circulating RBC count of the Sk-HB mice is similar to the Sm-HB mice; however, the RBC count is lower in the Sk-NB mice than the Sm-NB mice (A). The spleen cell number in the Sk-HB mice is lower than the Sk-NB mice (B). The splenic monocyte and neutrophil levels return to Co levels in both Sk groups (C). The Sk-HB mice demonstrate immune dysregulation at 6 and 12 days postflight.

Conclusions

- During intercontinental aeromedical transport, the presence of HB may not increase the need of blood products to restore and maintain the RBC count after HS.
- Intercontinental aeromedical transport may affect host defense.

Acknowledgment

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