Emergency Medicine Residency Training Program, York, PA, USA,

³*Department of Emergency Medicine, University of Alabama at Birmingham, Birmingham, AL, USA*

Objective.—To create a longitudinal wilderness medicine curriculum or track that can be incorporated into an emergency medicine (EM) residency program.

Methods.—Interest-specific tracks are becoming increasingly popular in EM training. We chose this model to develop our curriculum specific to wilderness medicine (WM). This curriculum may be incorporated into an EM training program. This training would facilitate transition to a WM fellowship or other career in the field for the interested resident. Outlined is a 3-year longitudinal course of study that includes a core didactic curriculum and a plan for graduated levels of responsibility. The core content is specifically related to the required EM core content for residency training. The track enhances the WM specific core content for the EM residents as a whole, in addition to providing each WM track resident with additional focused WM didactics, skills, and teaching opportunities. Finally, the track allows the resident to align his or her research, didactic, and administrative project requirements of the EM program within the field of WM study. The WM track curriculum is easily modified to fit the particular needs of individual residency programs.

Results.—We present a model core content curriculum for a WM track for training within an EM training program.

Conclusions.—This WM curriculum would give residencies a framework that can be used to foster learning for the residents interested WM. It enhances the coverage of wilderness core content education for all of the EM residents in the program. It provides wilderness- and environmental-specific education and experience for interested residents, allowing them to focus on an area of study, enhancing their CVs at graduation. Finally, given the popularity of WM, the presence of a WM track may potentially improve recruitment for the residency program.

Prospective Double-Blinded Randomized Field-Based Clinical Trial of Metoclopramide and Ibuprofen for the Treatment of Acute Mountain Sickness

Hillary R. Irons, MD, PhD¹; Renee N. Salas, MD¹; Salman

F. Bhai, MD²; N. Stuart Harris, MD¹

¹*Massachusetts General Hospital, Boston, MA, USA,* ²*Brigham and Women's Hospital, Boston, MA, USA*

Introduction.—Acute Mountain Sickness (AMS) afflicts 50% to 80% of high-altitude travelers, and can be debilitating. AMS is defined as headache with nausea/vomiting, fatigue/weakness, dizziness/lightheadedness, and/or difficulty sleeping because of rapid ascent. Because patients with AMS often are nauseated, metoclopramide may be a solution, as it treats nausea and migraine headaches. Studies also suggest ibuprofen as effective AMS therapy.

Objective.—Assess the effectiveness of metoclopramide compared with ibuprofen for AMS treatment.

Methods.—We performed a prospective, double-blinded, randomized, field-based clinical trial of 10 mg metoclopramide vs 400 mg ibuprofen for AMS treatment. Enrollment was March to May 2013 and March to April 2015 along the approach to Mount Everest in Pheriche (4280 m) and Dingboche (4358 m), Nepal. Eligibility criteria were ≥ 1000 vertical feet gain over 24 hours with a headache and one other AMS symptom. Patients with severe AMS, high altitude cerebral edema, or high-altitude pulmonary edema were excluded. Subjects were assessed by vital signs, Lake Louise Score (LLS), and a Visual Analog Scale for headache and nausea severity immediately prior to treatment, and then serially at 30, 60, and 120 minutes afterwards. Results were analyzed by signed-rank and Wilcoxon rank-sum tests (P values $< .05$ considered significant).

Results.—Analysis revealed no significant differences between metoclopramide and ibuprofen groups with respect to age, sex, initial LLS, heart rate, or oxygen saturation. Both medications significantly reduced headache severity and nausea compared with initial headache and nausea over the 2-hour study. At 120 minutes, metoclopramide additionally reduced nausea to a greater degree than ibuprofen, although both medications reduced overall AMS symptoms. When the LLS was used, there was a significant decrease in headache, dizziness, and total LLS with ibuprofen compared with metoclopramide.

Conclusion.—Both medications effectively reduced AMS symptoms, including headache and nausea. Metoclopramide additionally reduced nausea

more than ibuprofen. Therefore, metoclopramide may be an effective alternative AMS treatment, especially for patients with nausea.

Funding: WMS Houston Grant (2016).

Promoting Resilience Among Veterans Using Wilderness Therapy

Shauna Joye; Zachary Dietrich

Georgia Southern University, Statesboro, GA, USA

Introduction.—Mental health problems are common among combat veterans. Although the US government has set aside resources to treat these individuals, long wait times, stigma related to receiving treatment, and the perception of few treatment benefits remain barriers for soldiers seeking mental-health services. One alternative to traditional psychotherapy is wilderness therapy, which uses the natural environment to promote recovery.

Objective.—The purpose of the present research was to expand on the literature and our previous findings by measuring the mental health of 7 groups of combat veterans on long-distance (ie, 4–6 months) hiking and paddling trails.

Methods.—Veterans completed pre-, mid-, and posthike measures aimed at gauging their mental-health functioning. We also emailed them weekly psychoeducational messages about how they might think and behave in ways to promote well-being. For 3 of the trails, we hiked with the veterans for 2 days at the beginning of their wilderness experience.

Results.—Preliminary data analyses for veterans in our wilderness therapy program vs those in a waitlist control group indicated larger gains in mental health across 11 variables for those in the treatment group. Even with a small sample size ($N = 31$), we found statistically significant differences between groups for anxiety ($P < .001$), phobic anxiety ($P = .04$), and interpersonal sensitivity ($P = .03$), and a marginally significant difference in overall mental health ($P = .06$).

Conclusions.—For a generation of post-9/11 combat veterans who may not benefit from traditional approaches to therapy, our wilderness therapy program showed promise as a way for veterans to address issues related to experiencing traumatic events while deployed. We found significant decreases in general anxiety, anxiety related to fear or uneasiness when in new places and around crowds, and feelings of wariness or self-consciousness around others.

Funding: WMS Hackett-Auerbach Grant (2015).

Ambulatory Blood Pressure Monitoring Reveals Increased Sleeping Blood Pressure in Hypertensive Individuals at High Altitude

David S. Young, MD, MS¹; Linda E. Keyes, MD¹; Luke F. Mather, MD²; Charles Duke³; Nirajam Rejmi, MD⁴; Benoit M. Phelan, MD⁵; Sushil Pant, MD⁴; Jennifer M. Starling, MD¹; Matthew K. McElwee⁶; Devlin Cole⁶; Theodore McConnell⁷; Purshotam Paudel⁴; Douglas; Sallade⁸; Allison L. Sheets, MD⁹; David R. Twillman¹; Buddha Basnyat, MD¹⁰

¹*University of Colorado Denver School of Medicine, Aurora, CO, USA,*

²*University of Washington School of Medicine, Seattle, WA, USA,*

³*University of Tennessee Health Science Center, Memphis, TN, USA,*

⁴*Mountain Medicine Society of Nepal, Kathmandu, Nepal,* ⁵*Dalhousie*

University Faculty of Medicine, Halifax, NS, Canada, ⁶*Case Western*

Reserve University School of Medicine, Cleveland, OH, USA, ⁷*McGill*

University, Montreal, QC, Canada, ⁸*Philadelphia College of*

Osteopathic Medicine, Philadelphia, PA, USA, ⁹*Longmont United*

Hospital, Longmont, CO, USA, ¹⁰*Oxford University Clinical Research*

Unit Nepal, Patan, Nepal

Introduction.—For those traveling to high altitude, it has been postulated that blood pressure (BP) changes when compared to sea level. Also at altitude, periodic breathing has been well described and is correlated to decreased sleep quality.

Objective.—Measure continuous sleeping and awake blood pressures in both normotensive and hypertensive Himalayan trekkers.

Methods.—Blood pressure was measured with Welch-Allyn 6100 24h ambulatory BP monitors (24h-ABPM) every 30 minutes while awake and every

60 minutes while asleep. Baseline demographic data were obtained on arrival at 2860 m and 24h-ABPM measured between 2860 to 3440 m and 3440 to 4400 m. Hypertensive subjects were defined by self-reported diagnosis of hypertension (HTN). Acute mountain sickness was measured by Lake Louise Score (LLS).

Results.—Eight subjects were enrolled, 4 with pre-existing treated HTN. Data were insufficient or incomplete for 2 subjects with HTN. Between 2860 and 3400 m, the 4 normotensive subjects (NTN) had the expected decrease in BP during sleep. Mean arterial pressure (MAP) decreased from an average of 95 mm Hg (95% CI, 89.76–100.24 mm Hg) while awake to 82.5 mm Hg (95% CI, 74.72–90.28 mm Hg). The 2 with HTN had an increase in BP from awake hours (95.5 mm Hg [95% CI, 84.81–106.11 mm Hg]) to sleep (112.5 mm Hg [95% CI, 100.48–124.52 mm Hg]). The observed pattern in awake vs sleeping BP was similar between 3440 and 4400 m, ($N = 4$, 3 NTN, 1 HTN). The NTN had an average awake MAP of 94.67 mm Hg (95% CI, 90.1–99.24 mm Hg) that decreased to 86 mm Hg (95% CI, 74.03–97.97 mm Hg) and the HTN subject had an increase from awake MAP (90 mm Hg) to sleep MAP (106 mm Hg). No subject developed AMS at any altitude. No differences in heart rate, maximum or minimum BP, or number of BPs above normal were found between NTN and HTN groups at altitude.

Conclusions.—These findings suggest that those with baseline HTN may have an increase in BP while sleeping compared with NTN individuals at high altitude. The clinical significance of these findings remains to be studied.

Funding: WMS Hultgren Grant (2015); Nepal International Clinic.

The Effect of Riociguat on Gas Exchange, Exercise Performance, and Pulmonary Artery Pressure During Acute Altitude Exposure

Jon Andrews¹; Stefanie Martina¹; Michael Natoli¹; Nicole Harlan¹; Luke Neilans²; Miguel Alvarez Villela¹; John Freiburger¹; Aaron Walker¹; Ishwori Dhakal¹; Richard Moon¹

¹Center for Hyperbaric Medicine and Environmental Physiology, Department of Anesthesiology, Duke University Medical Center, Durham, NC, USA, ²Department of Pulmonary, Allergy, and Critical Care Medicine, Department of Medicine, Duke University Medical Center, Durham, NC, USA

Introduction.—Impairment of exercise performance during altitude exposure results in hypoxemia and decreased oxygen delivery to exercising muscles. Hypoxic pulmonary vasoconstriction (HPV) and ventilation/perfusion (V_A/Q) mismatch further contribute to hypoxemia. Therefore, if pharmacologic blockade could attenuate HPV, then V_A/Q matching, arterial PO_2 , and exercise performance might improve. The nitric oxide (NO) pathway has been targeted in this context with sildenafil, but NO is limited at high altitude, which may explain the variable effectiveness of this approach. Riociguat is a soluble guanylate cyclase stimulator that does not require NO for its action.

Objective.—To examine the acute effect of riociguat on pulmonary artery pressure, arterial oxygenation, and exercise performance at 15,000 feet simulated altitude.

Methods.—Subjects instrumented with radial and pulmonary artery (PA) catheters performed incremental exercise tests on a bicycle ergometer at a simulated altitude of 15,000 feet before and after administration of 1 mg riociguat. The following parameters were measured: mean and PA pressures, pulmonary vascular resistance (PVR), systemic vascular resistance (SVR), heart rate (HR), cardiac output, arterial and mixed venous O_2 saturation, alveolar-arterial PO_2 difference, oxygen consumption (VO_2), and arterial O_2 delivery (DO_2). Statistical analysis was performed using a generalized estimating equation model, and the effect of riociguat on outcome was examined, accounting for exercise impact.

Results.—Preliminary results ($N = 11$ subjects) demonstrated decreased PVR ($P = .014$), while DO_2 and cardiac output were increased ($P < .01$) at rest and at 50 W of exercise intensity after administration of riociguat. There was no statistically significant effect on mean arterial or PA pressures, arterial O_2 saturation, alveolar-arterial PO_2 difference, or VO_2 .

Conclusion.—We conclude that at 15,000 feet simulated altitude, a one-time dose of 1 mg riociguat appears to decrease pulmonary vascular resistance

while increasing peripheral O_2 delivery and cardiac output at rest and low exercise levels.

Funding: Hackett-Auerbach Grant (2014).

The Influence of Snow Density on O_2 and CO_2 Levels in Subjects Breathing into an Artificial Airpocket

Giacomo Strapazzon¹; Kai Schenk¹; Peter Paal²; Markus Falk¹; Tomas Dal Cappello¹; Katharina Grassegger²; Sandro Malacrida¹; Hannes Gatterer³; Lukas Riess²; Benjamin Zweifel⁴; Jürg Schweizer⁴; Hermann Brugger¹

¹EURAC Institute of Mountain Emergency Medicine, Bolzano, Italy,

²Department of Anaesthesiology and Critical Care Medicine, Innsbruck University Hospital, Innsbruck, Italy, ³Department of Sport Science, Medical Section, University of Innsbruck, Innsbruck, Austria, ⁴WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

Introduction.—Survival time in an avalanche depends on factors such as patency of the airway and the volume of an airpocket. It also was suspected that the characteristics of snow, especially snow density, affects the development of hypoxia and hypercapnia.

Objective.—To evaluate the influence of snow density on the development of hypoxia and hypercapnia in subjects breathing into an artificial airpocket.

Methods.—Twelve male healthy subjects breathed through an airtight face mask and 40-cm tube into an artificial airpocket of 4 L. Every subject performed 3 tests on different days with variable snow densities (range 155–481 kg/m³). Symptoms, gas, and cardiovascular parameters were monitored for up to 30 minutes. Tests were interrupted at $SpO_2 < 75\%$. Snow density was measured around the airpocket. A scatterplot of rate of CO_2 decrease and O_2 increase in the airpocket per snow density revealed 2 clusters (snow density $\leq$ or > 250 kg/m³) that were confirmed by a 2-step cluster analysis. The second cluster then was divided by the median of about 400 kg/m³ into 2 subgroups. Test duration was analyzed by means of Kaplan-Meier estimator and log-rank test.

Results.—Eighteen of 36 test subjects completed the test duration of 30 minutes. Test duration was different in the 3 groups of snow density ($P < .05$) and was shorter in the highest density group than in the other 2 groups ($P < .05$). Test duration in the lowest and middle snow density groups was not different ($P > .05$).

Conclusion.—Snow density > 250 kg/m³ was positively correlated with difference from baseline to maximum value of CO_2 and negatively correlated with difference from baseline to minimum value of O_2 levels. Unexpectedly, lower densities showed a different behavior on CO_2 levels that could affect survival in avalanche-buried victims.

Burial Duration and Airpocket Explain Avalanche Survival Patterns in Austria

Emily Procter¹; Giacomo Strapazzon¹; Tomas Dal Cappello¹; Andreas Würtele²; Andreas Renner¹; Benjamin Zweifel³; Markus Falk¹; Hermann Brugger¹

¹EURAC Institute of Mountain Emergency Medicine, Bolzano, Italy,

²Austrian Board of Alpine Safety and Avalanche Research SLF, Innsbruck, Austria, ³WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

Introduction.—An avalanche survival curve is a graphical representation of the cumulative survival probability during complete avalanche burial as a function of time. Thus far, survival patterns have been calculated using data from Switzerland and Canada.

Objective.—To calculate an avalanche survival curve using data from Austria.

Methods.—The analysis included avalanche accidents between 2005 and 2006 and 2012 and 2013 in Austria involving completely buried victims (ie, burial of the head and chest) in open terrain with known outcome at hospital discharge (survived or did not survive). Extrication and survival curves were calculated using the Turnbull algorithm, as in previous studies.

Results.—Three hundred thirty-three completely buried victims were included. Median time to extrication was 15 minutes (25th to 75th quartile: 5–50 minutes). Overall survival was 59%. The survival curve showed a rapid