initial drop in survival probability and a second drop to 18% between 20 and 40 minutes burial, where an inflection point exists and the curve levels off. Victims with an airpocket were more likely to survive compared with those without, especially for victims buried >15 minutes.

Conclusion.—The Austrian survival curve resembles previously published curves and suggests that underlying survival patterns are reproducible. The results are in accordance with current recommendations for management of avalanche victims and serve as a reminder that expedient companion rescue is critical for survival. For the first time an airpocket was shown to be a positive prognostic factor for survival.

Medical and Logistical Challenges of the Longest Cave Rescue: A Case Report

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Introduction.—Trauma care in cave rescue is a unique situation in wilderness medicine with extremely long prehospital time. Environmental and logistical factors limit therapeutic options and transport and also can influence survival and outcome.

Objective.—To describe trauma care during the longest cave rescue reported to date.

Methods.—Case report of a 53-year-old male patient with a severe head injury at a depth of about 1000 m from the cave entrance in Bavaria, Germany.

Results.—Search and rescue (SAR) operation required 12 days until evacuation. SAR activation was delayed because of the location of the accident, and it required several days to recruit experienced cave rescuers and medical teams. More than 700 rescuers were involved, including 7 physicians from 5 different countries. Basic first aid was performed by companions in the acute phase and prevented the patient, who sustained a severe traumatic brain injury, from developing severe hypoxia. Thereafter, professional medical care was limited to continuous monitoring and basic therapeutic measures by medical personnel because of the extremely confined space in the cave and long evacuation time. At 6-month follow-up, the patient had recovered completely and resumed his job.

Conclusion.—First aid education and training and international collaboration of cave rescue teams play an important role in cave accidents. However, trauma care often relies on expert knowledge and is not yet evidence-based practice.

A Review of Search and Rescue Operations in Slovenia

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Introduction.—Adventure recreation in wilderness areas across the world has continually increased in popularity in recent years. In response, more intensive study has been devoted to analyze and compare search and rescue programs. Furthermore, less emphasis has been put on rescue programs in smaller European countries with rich histories of mountain travel and rescue, where development of rescue systems is ongoing.

Objective.—To document trends in professional mountain rescue operations performed in Slovenia from 2011 to 2015.

Methods.—This study is a retrospective case series which uses information detailing rescue and recovery operations. Data were obtained from the Slovenian National Mountain Rescue Association. This study reports longitudinal trends in numbers of rescues and compares numbers of both on-foot and helicopter-supported rescues. We also compared data on causes of activation of search and rescue and interventions requiring use of a helicopter in 2015 and the severity of injuries requiring evacuation.

Results.—Altogether there were 434 mountain rescue operations in 2015. Among those involved, 206 (42%) were injured, 176 (36%) did not require

treatment, 48 (10%) were due to illness, and 40 (8%) were found dead. The most frequent type of injury was lower extremity, and the most frequent cause of illness was exhaustion. One hundred ninety interventions (44%) used a helicopter. Of these, 49% were injured, 29% required no medical treatment, 15% were ill, and 7% of the patients were found dead.

Conclusions.—The number of reported rescues preformed in the 5-year study period did not vary significantly despite increases in total mountain rescues throughout previous decades. A notable number of operations in the past year required the use of a helicopter, and the majority were the result of an injured patient. This study will help provide an understanding of incidents that arise in the Slovenian mountains and the response rescue services provided.

How Effective Is a Dental Skills Workshop in Improving the Knowledge and Confidence of Medical Students and Residents in Management of Dental Emergencies?

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Introduction.—Millions of people experience dental trauma while participating in wilderness activities. Many physicians and medical students report rarely having had any education in this field. The purpose of this study was to evaluate the effect of a 3-hour hands-on workshop for medical students and residents on their pre- and postcourse knowledge and confidence in managing dental emergencies.

Materials and Methods.—A 1-hour lecture followed by four 20-minute “hands-on” skill stations on dental mannequins was administered to a group of medical students and residents. Pre- and postworkshop questionnaire surveys were conducted.

Results.—There was a significant increase in the percent of lecture attendees who responded correctly to 3 of the 4 knowledge questions ($P < .005$). Confidence in various statements about treating dental emergencies was significantly different after the lecture for 8 of the 9 statements. At baseline, the majority disagreed with statements implying confidence in handling various aspects of dental emergencies. At follow-up, there was an apparent trend toward confidence.

Conclusion.—Our findings suggest that dental education is minimal during undergraduate and graduate medical training. Our interactive workshop appeared to be effective in increasing the knowledge and self-reported confidence of medical practitioners in handling dental emergencies. Based on findings from this workshop, it seems there is a need for additional dental education during medical school, especially with regard to managing dental emergencies, dental anesthesia, and dental nomenclature.

Battlefield Analgesia and Adherence to TCCC Guidelines: A Quality Assurance Analysis

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Introduction.—Previous studies have demonstrated low rates of prehospital analgesia and adherence to Tactical Combat Casualty Care (TCCC) guidelines in the Joint Theater combat setting. The reasons for this remain unclear. We seek to expand on previous reports by evaluating a larger prehospital data set and seek associations with various factors associated with analgesia or lack of analgesia administration.

Methods.—This was part of an approved quality assurance project to evaluate adherence to TCCC guidelines across multiple modalities. Data were obtained using the Prehospital Trauma Registry (PHTR). The PHTR was in existence from January 2013 through September 2014. This database obtained data from TCCC cards, DD 1380 forms, and after-action reports (AAR) to provide real-time feedback to units on prehospital medical care.

Results.—Note that this is a preliminary analysis; full analysis will be available for the conference. During the PHTR's existence, 705 patient

encounters occurred. Those who had an open wound were more likely to receive pain medication vs those who did not have an open wound (46% vs 7%, $P < .001$). There was a trend toward more pain medications administered to penetrating wounds vs blunt trauma (28% vs 14%, $P = .07$). If an antibiotic was given, the patient was more likely to receive pain medication (66% vs 19%, $P < .001$). Patients transported by AIREVAC were more likely to receive pain medication (35% vs 20%, $P = .004$). If a tourniquet was placed, patients were more likely to receive pain medication (47% vs 32%, $P < .001$). Medical officers were more likely to administer pain medications (43% vs 17%, $P < .001$).

Conclusions.—There were higher rates of pain medication administration for open wounds vs closed wounds, penetrating trauma vs blunt trauma, co-administration of antibiotics, AIREVAC vs ground evacuation, tourniquet placement, and treatment by a medical officer. A more detailed analysis by analgesia agent and whether the agents were within TCCC guidelines will be performed.

Medical Problems of Casualties and Rescuers in the 2014 Volcanic Eruption in Japan

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Introduction.—There are many active volcanoes worldwide that are popular destinations for tourists and trekkers. Mt. Ontake (3067 m), the second highest volcano in Japan and a popular mountain because it is a relatively easy climb, erupted without apparent warning and led to a heavy loss of life on September 26, 2014. Volcanic eruption disaster is an uncommon medical emergency and practical medical experience is limited in the medical literature.

Objective.—To consider the medical role and develop medical planning for emergencies during volcanic mountain disasters.

Methods.—Collected data included photos and movies provided by military, national police, and fire defense agency sources, in addition to publicly available data from the cabinet office.

Results.—Fifty-seven deaths, 6 losses, and at least 26 rescued. The primary cause of death was trauma by abrupt fallen rocks; victims died instantly. Survivors also experienced trauma due to abruptly fallen rocks. The location of dead bodies was concentrated on the mountain trails within a 1 km-radius from the craters. More than 20,000 rescuers engaged in a search and rescue for 20 days, until winter set in. No deaths of rescuers occurred, but some had acute mountain sickness and hypothermia on missions.

Conclusions.—The volcano erupted violently and rapidly, leaving little or no time for people to escape or take shelter. Emergency medical care played a small role in this severe volcanic eruption. On the other hand, precautionary education about health hazards and medical care for rescuers is necessary and helpful.

Canyoneering-Related Search and Rescue in Zion National Park from 2005-2015

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Introduction and Background.—Canyoneering is an increasingly popular outdoor activity within Zion National Park (ZNP) in Utah, yet the burden of this particular activity on search and rescue (SAR) resources is relatively unknown. ZNP maintains records from all SAR activations. Although a recent review of canyoneering rescue operations in Spain has been published, there has been no review of canyoneering SAR records in the United States until now.

Objectives.—To examine demographics of parties involved, relevant injury patterns, and cost of SAR response in canyoneering-related SAR activations in ZNP from 2005 to 2015.

Methods.—ZNP provided 221 SAR records for incidents in which the activity was noted to be “canyoneering” between January 1, 2005 and December 31, 2015. Annual reports of all ZNP SAR activations from 2005 to 2015 also were obtained.

Results.—Out of 221 SAR activations from 2005 to 2015, there were 562 people involved. There was a male ($n = 283$) to female ($n = 104$) ratio of 2.7:1 for activations in which the sex of canyoneering parties was noted. One hundred

eighteen people were recorded as ill or injured; there were 72 ill/injured men and 37 ill/injured women. The most common injuries were ankle injuries (25.2%), followed by other lower extremity injuries (15.9%), knee injuries (11.2%), and illnesses attributable to environment/exposure (11.2%). The most common age range of 378 canyoneers with recorded ages was 20-29 ($n = 137$, 36.2%). There were 11 total fatalities in the 10-year period, with primary contributing factors to deaths being flash flooding ($n = 7$), falls ($n = 3$), and drowning vs exposure ($n = 1$). Average cost of canyoneering-related SAR operations was \$3483.33 over the 10-year period.

Conclusions.—Canyoneering-related SAR contributes significantly to use of ZNP resources, with canyoneering-related SAR expenses making up 40.4% of the 10-year total SAR cost. Injury occurred in 51% of all canyoneering SAR activations in the 10-year period. Canyoneers should take measures to prevent lower extremity injuries as well as illness related to environment and exposure and should be prepared to manage such issues if they arise. Medical providers in national parks where canyoneering occurs should familiarize themselves with these injury patterns and methods to manage them in the backcountry.

Direct Measurement of Intracranial Pressure in Hypobaric Hypoxia: Implications for Acute Mountain Sickness

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Introduction.—Despite decades of research, the pathophysiology of acute mountain sickness (AMS) is unknown. The classic hypothesis is that persistent and/or transient elevations in intracranial pressure (ICP) cause AMS.

Objective.—To make continuous, direct, invasive measurements of ICP alongside AMS (Lake Louise Questionnaire [LLQ]) in hypobaric hypoxia (4500 m).

Methods.—To date, we have recruited three men who had previously been cured of a hematologic malignancy and as such had an Ommaya reservoir implanted. A needle was placed inside the Ommaya reservoir for direct measurement of intraventricular pressure.

Results.—Participant 1: ICP at sea level was 13 mm Hg. After 9 hours at altitude, mean ICP remained normal (14 mm Hg), but large fluctuations in ICP (>20 mm Hg) were observed, alongside symptoms of AMS (LLQ, 6). Administration of 100% O₂ stabilized ICP and symptoms resolved. With removal of 100% O₂, ICP pressure waves began and symptoms returned. Participant 2: ICP decreased slightly at altitude (SL, 11 vs altitude, 6.6 mm Hg) and no pressure waves were observed over the first 9 hours. This subject reported only a very mild headache. During sleep, ICP fluctuated in opposition to oscillations in SaO₂. The participant woke with mountain sickness (LLQ = 10), which declined by 24 hours (LLQ = 4), where ICP was below the sea level value (3 mm Hg). Participant 3: ICP at sea level was 16 mm Hg. After 9 hours at altitude, ICP was substantially elevated (26 mm Hg) with symptoms of AMS (LLQ = 5). ICP was persistently >20 mm Hg while asleep, and the participant woke with muscle paralysis and severe AMS. Administration of 100% O₂ reduced ICP (11 mm Hg) and resolved symptoms. This study was ended because of the possibility of mild cerebral edema.

Conclusions.—These preliminary observations suggest that persistent or transient elevations in ICP preceded the onset of AMS.

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Metal Accumulation in Horseshoe Crab (*Limulus polyphemus*) Eggs, Embryos, and Larvae From Potentially Contaminated Public Beaches

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Introduction.—In many coastal ecosystems, humans and marine organisms are confronted with heavy metal contamination. Thus, such organisms could be used as a bioindicator to understand uptake pathways and the potential risks of these habitats to marine organisms and human health.

Objective.—To relate 13 different trace metal concentrations between surrounding habitat and accumulation levels across early life stages of horseshoe