Selected Abstracts From the Wilderness Medical Society's 2009 Annual Scientific Meeting

Avalanche Beacon Reception Under Water: A Pilot Study Applying Avalanche Beacon Technology to Improve Scuba Diver Situational Awareness

Lost, disoriented, or entangled scuba divers are at risk of asphyxiation due to low air supply: time-sensitive situations that depend on timely “buddy rescue.” Similarly, avalanche victims die most frequently from asphyxiation if not rescued by a nearby buddy, with survival probability decreasing quickly, from 91% at 18 minutes after burial to 34% at 35 minutes. In these situations where elapsed time until rescue is one of the most critical variables of survival, using an avalanche beacon has resulted in a lower median duration of burial (5 minutes vs 125 minutes; $P < .001$) and rate of mortality (55.2% vs 70.6%; $P < .001$, odds ratio 0.26) when compared to avalanche victims not using a beacon. This knowledge and technology have made avalanche beacons part of standard backcountry travel gear and are now helping firefighters locate lost comrades and build exits when visual communication is impaired.

Scuba divers in low visibility situations may also benefit from a personal, hand-held device that helps locate their buddy if visual communication is lost. Modern day avalanche beacons may serve this purpose.

Initial testing was carried out in the shallow end (3-foot depth) of a local 100-foot by 50-foot swimming pool. Four submerged, identical, opaque, watertight lexan cases were submerged to the bottom in the four corners of the pool's shallow end. One of the cases contained a Tracker DTS avalanche beacon in “transmit” mode. Volunteers used an identical avalanche beacon in “search” mode, and encased in a similar but clear, water-tight case, to identify which of the 4 cases contained the missing beacon. Ten out of 10 volunteers, each with minimal training and within 1 minute 30 seconds, were able to use the “tracking” beacon to locate the “missing” beacon. Avalanche beacon reception under water is possible and warrants further study applying its technology to underwater applications.

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The Ultrasound Identification of Simulated Long Bone Fractures by Prehospital Providers

Objective.—In the wilderness and other austere environments, decisions regarding patient management are often limited by obtainable resources. Portable ultrasound may allow for the detection of fractures in areas where other imaging modalities such as radiography are not readily available. We used a

simulation training model for the ultrasound diagnosis of long bone fractures to study the ability of emergency medical technicians (EMTs) to detect the presence or absence of a variety of simulated fracture patterns using a portable ultrasound.

Methods.—The fracture simulation model is composed of a bare turkey leg bone that is mechanically fractured and housed in a shallow plastic container within a completely opaque gelatin base solution. Five different fracture patterns were created: no fracture, transverse fracture, segmental fracture, oblique fracture, and comminuted fracture. Twenty EMTs then sonographically evaluated these 5 models with a SonoSite M-Turbo portable ultrasound device for the presence or absence of a fracture.

Results.—EMTs correctly identified the presence or absence of a fracture in the models with no fracture, a transverse fracture, and an oblique fracture 95% of the time. Participants always correctly identified the presence of a fractured model when assessing the comminuted and segmental fracture model. Across detection of all fracture patterns, a final sensitivity of 97.5% (95% confidence interval [CI]: 94.1%–100.0%) and a specificity of 95.0% (95% CI: 85.4%–100.0%) was observed in our study.

Conclusions.—Using a portable ultrasound device, EMTs were able to correctly detect the presence or absence of a simulated long bone fracture with a high degree of sensitivity and specificity. Future studies may further evaluate the ability of other groups to use ultrasound to assist in the diagnosis of fractures, as well as examine the clinical impact of this skill in environments where conventional imaging modalities are limited or unavailable.

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Predictive Factors of Successful Summiting on Aconcagua

Background.—Base camp physicians and expedition leaders commonly measure static vital signs when screening mountaineers prior to summit attempts. Single measurements of functional status such as the 6-minute walk test (6MWT) and postexercise vital signs (VS) have not been described at high altitude.

Objective.—Determine if postexercise VS or 6-minute walk distance (6MWD) predicts successful summiting at extreme altitude on Aconcagua.

Methods.—Prospective observational cohort study. *Setting:* Plaza de Mulas base camp (4365 m) Aconcagua Provincial Park, Argentina. *Inclusion criteria:* volunteer trekkers to

Aconcagua (6962 m) during January 2009 who signed written informed consent. *Exclusion criteria:* pregnant women, age <18 years. *Study protocol:* VS were measured before and after completion of a 6MWT using a standardized protocol on a 40-m course while acclimatizing at 4365 m. Subjects proceeded towards the summit at their own pace and returned a questionnaire with maximum altitude reached upon descent. *Statistical analysis:* means, 95% confidence intervals, and *t* tests were calculated using Stata.

Results.—Sixty-five subjects completed the 6MWT and returned their questionnaires. Thirty-six (55%) climbers reached the summit (6962 m). Mean maximum altitude reached was 6487 m. Among climbers who reached the summit, mean resting Sao_2 : 86.3%, mean 6MWD: 482.9 m, mean postexercise Sao_2 : 80.8%, and mean ΔSao_2 : -5.5%. Among climbers who did not reach the summit, mean resting Sao_2 : 83.9%, mean 6MWD: 451.8 m, mean postexercise Sao_2 : 76.5%, and mean ΔSao_2 : -7.4%. Between the 2 groups, the differences of the mean were as follows: resting Sao_2 , -2.3% (95% CI: -4.4 to -0.3; $P = .013$); 6MWD, 31.1m (95% CI: -9.4 to 71.5; $P = .065$); postexercise Sao_2 , -4.3% (95% CI: -6.6% to -1.9%; $P = .0003$); and ΔSao_2 , -1.9% (95% CI -4.2 to 0.4; $P = .048$).

Conclusions.—Climbers who successfully reached the summit of Aconcagua were less hypoxic and performed better on 6MWT compared with those who did not. Future studies with larger sample sizes are needed to validate these results.

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Intra-articular Sea Urchin Spine/Foreign Body Evaluation: Ultrasound Versus Fluoroscopy

In an out-of-hospital setting, evaluation for soft-tissue foreign bodies after impalement with a sea urchin spine can be challenging, with management options consisting of nonsurgical management or local surgical exploration. However, when an intra-articular foreign body is suspected, transfer to a hospital setting is often required for radiographic evaluation and surgical removal. Ultrasound (US) evaluation may allow for determining in the field if joint involvement is present, possibly eliminating patient transport to a health care facility. Our objective is to evaluate the effectiveness of bedside US in accurately determining the absence of an intra-articular foreign body in comparison to fluoroscopy and computed tomography (CT).

This was a prospective blinded study to determine the utility of US and fluoroscopy to detect an intra-articular foreign body. The largest joint in a skin-on chicken thigh was the target for the foreign body insertion. A single spine from a freshly harvested Uni sea urchin was introduced through the skin of the

chicken, directed towards the joint. The spines were very fragile, and introduction caused the spine to break leaving no evidence of the location of insertion. As a result, the investigator was unable to determine the final position of the spinous tip. Each chicken quarter was evaluated for the presence of an intra-articular foreign body by 3 methods: bedside US, fluoroscopy, and CT. A separate investigator performed each modality and was blinded to the other's results. US evaluation was performed by an emergency medicine physician (EMP) with hospital credentials for emergency US using a SonoSite MicroMaxx US machine with a linear probe. Fluoroscopy was performed by a second EMP using a GE series 9600 fluoroscopy system. There was no time limit for the evaluation of the quarter by either fluoroscopy or US. Using a GE Lightspeed VCT2 CT scanner, 0.625-mm slices (joint protocol) were acquired to evaluate the location of the foreign body. If the foreign body violated the joint capsule, then the interpreting radiologist classified the foreign body as intra-articular. Descriptive statistics were used to report the accuracy of each modality for the detection of intra-articular foreign bodies. All values are reported with a 95% confidence interval (CI).

Six of the 10 trials resulted in the spine penetrating the joint capsule. Ultrasound detected 9 of the 10 foreign bodies. There was one false positive result for joint penetration, yielding a sensitivity and specificity for detecting the intra-articular foreign body of 100% (95% CI: 46.3%–100%) and 75.0% (95% CI: 21.9%–98.7%), respectively. Fluoroscopy detected all 10 foreign bodies but had one false positive result for joint penetration, yielding a sensitivity of 100% (95% CI: 51.7%–100%) and specificity of 75.0% (95% CI: 21.9%–98.7%). The false positive result of both US and fluoroscopy occurred with the same foreign body.

CT remains the gold standard for detecting foreign body joint penetration. However, US may prove to be a valuable tool in identifying out-of-hospital joint penetration, thereby reducing unnecessary delay in treatment or hospital transfer.

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Intranasal Fentanyl for Analgesia in Injured Patients at a Ski Resort

Introduction.—Intranasal fentanyl has been shown to be a safe, effective mode of analgesic administration in prehospital, emergency department, and postoperative patients. We evaluated the use of intranasal fentanyl for initial analgesia in injured patients at a ski resort.

Methods.—We retrospectively reviewed the charts of 46 injured adult and pediatric patients treated with intranasal fentanyl during the 2007–2008 winter ski season. Patients were treated with fentanyl according to online Medical Control Emergency Physician (MCEP)-approved doses (approximate dose 1.4 $\mu\text{g/kg}$), using 50 $\mu\text{g/mL}$ concentration fentanyl ad-