Foreword to Wilderness Medicine 6th Ed.
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Two hours into my first trans-Pacific flight to Hong Kong (on my way to Nepal), a flight attendant put out a call to see if there was a physician on board. I raised my hand and was taken to see a 22-year-old American soldier who was suffering a moderately severe allergic reaction to peanuts. The young man was flushed, had a diffuse urticarial rash, and felt some swelling in his throat. He was so itchy he could not sit still. The reaction had been going on for 45 minutes. As I looked him over, the captain of the plane came down the aisle to talk to me.

“We're as close as we're going to be to Anchorage,” he said. “We can dump the entire trans-Pacific load of fuel and land there, if you say so.”

I greeted this with disbelief. A few hours into my first trip to Asia, and suddenly I was in charge of the plane. I did not want to land in Anchorage if we did not have to (apart from not wanting to dump 40,000 gallons of fuel into the ocean). I asked the flight attendants to bring me the first-aid kit from the plane. I would give the soldier a shot of epinephrine and an antihistamine tablet, and we could keep going.

“We don't carry a first-aid kit,” came the reply. “We have a few bandages, that's it.”

I looked at the soldier. I did not think he was in danger of dying, but it would be a long flight for him with itchy skin and a swollen face. On the other hand, hundreds of people would be delayed a day or more, at a cost of hundreds of thousands of dollars, if we diverted to Anchorage. It occurred to me that someone on a Boeing 747 with 400 passengers might be carrying a bee sting kit. I asked the flight attendant to make an announcement, and three people raised their hands. I accepted one of the kits, injected the soldier, gave him some diphenhydramine, and watched him quickly improve. I told the captain that we could continue flying to Hong Kong.

Solving problems with what you have at hand is one of the main themes of wilderness medicine, a discipline that had yet to evolve in 1979 when I was on that flight. Ten days later, I was trekking on my way to the Himalayan Rescue Association Aid Post at Pheriche, a yak-herding village at 14,000 feet, near the base of Mt Everest. Eating dinner at a teahouse next to the Thyangboche monastery, I was asked if I could help an 84-year-old Sherpa man just up the valley in Pangboche. He had fallen down his stairs and sustained a scalp laceration the day before. I was not carrying suture supplies, but I had just visited the Kunde Hospital and was familiar with the staff, so I wrote a note to request instruments and suture material. A Sherpa runner carried the note and would return with the supplies the next morning.

In the morning, I walked a couple of hours to Pangboche, where I was led to the house of the man who had fallen down. He lay inside, moaning, and his hair was densely matted with blood. We carried him outside into the sun, where it was warm enough to work and there was good light. I put the instruments in a pot of water and boiled them on the hearth inside. I had no gloves and no sterile field. I poured povidone-iodine into the bowl that held the instruments and used the bowl as my sterile field, reaching into the disinfectant each time I needed to use an instrument. This kept both my hands and the instruments relatively sterile as I worked.

The laceration was truly major. It split the old man's right eyebrow and extended across his forehead and over the crown of his head to the back of his neck. A huge skin flap had been created, so I lifted it up and irrigated underneath it with copious quantities of water I had boiled earlier. I began to sew. The man moaned

and muttered as I worked. I asked one of the Sherpas what he was saying.

“He's saying, ‘Leave me alone. I just want to die.’ ”

I finished the repair and placed a padded dressing on his head. I gave instructions to his son and continued my
journey to the Pheriche aid post.

Three days later in Pheriche, the defining case in my wilderness medicine education arrived on the back of a yak. The patient being carried down the valley was a young New Zealand nurse named Barbara. She had not been feeling well for 2 days at 16,000 feet and was no longer able to descend under her own power.

Barbara was alert and oriented, although she appeared very tired. She denied having a headache, nausea, or shortness of breath over the past 2 days, and she had just descended 2000 feet. I gave her a cup of tea. She drank half the cup and then lay down and fell asleep. I sat in a chair across the room and watched her. I half-convinced myself that she looked a little blue, then talked myself out of it. She had just descended a considerable distance, with only mild symptoms of possible altitude illness. She could not have high-altitude cerebral edema (HACE). I continued this internal debate for about an hour, until I felt like I needed to know if she was okay.

I touched her shoulder and spoke her name. She did not respond. I shook her gently, and she shifted slightly and made unintelligible sounds. I shook her more vigorously, but she was unable to wake up. She was no longer just sleeping—she was unconscious.

There was no radio at the aid post. I sent a written note to the park ranger in Namche, requesting a helicopter rescue for early the next morning. I gave her intravenous dexamethasone and put an oxygen mask over her mouth and nose running at 2 liters per minute, trying to conserve the only two small bottles of oxygen that we had on hand. A little while later, she suddenly stirred and vomited all over her sleeping bag. Over the course of the night, she deteriorated steadily. I observed the effects of every additional drop of fluid that leaked into her brain. She became decerebrate, then flaccid, then unresponsive to deep pain. She was clearly dying. It was now just a matter of whether the helicopter would arrive in time. I felt very alone, wondering if there was anything more that I could do.

The night had been completely clear when I had stepped outside before taking a short nap. When I awoke at 6:00 A.M., it was snowing. I did not think a helicopter could fly through the mountains in a snowstorm. I had kept up my hope for rescue all night long, but at that moment I began to feel that she might not make it. When that thought hit me, I found myself emotionally unprepared to watch her die. Alone in a remote aid post, with one Sherpa helper and the patient's best friend, the circumstances were too intimate, the patient too like myself. I realized what it meant to do medicine in a wilderness setting. *You are on your own.* There is no one to call, no one to help. You just have to do the best you can with whatever limited resources you have.

At 10:00 A.M., a Sherpa arrived carrying a portable radio. This enabled me to tell the park ranger how desperate the situation had become. His response was not encouraging. He informed me that he had been unable to reach Kathmandu by radio to request a helicopter. Later in the day, he was finally able to contact Kathmandu, but the trekking company refused to guarantee payment for a helicopter evacuation. The park ranger offered to guarantee the money himself. It got worse from there. A helicopter was ready at the airport, but the pilot had gone home for the day. When they tried to telephone him, they found that the phone lines had just gone dead. By this point, Barbara was completely unresponsive to deep pain and barely

breathing at a rate of 4 times per minute. She had even lost her corneal reflexes.

At least it had stopped snowing.

I sat near the radio, waiting. The park ranger called again.

“Maybe we should just try to organize the helicopter for tomorrow,” he told me.

“She's going to die this afternoon if we don't rescue her,” I replied. “If you can't get a helicopter this afternoon,
there won't be any point in sending one tomorrow.”

“Got that,” said the ranger.

Another hour went by. Finally, I heard the ranger's voice.

“Pheriche, Pheriche, Pheriche. This is Namche. The pilot has landed here and set off fuel. He's on his way up the valley, but the weather is bad and he wants the patient ready to go.”

I pulled out the intravenous line, and we secured Barbara in her sleeping bag. Her friend would fly out with her. I stepped outside the clinic and looked down the valley. Clouds whipped past the peaks. I spotted the Alouette III helicopter emerging from the clouds. I had never before been involved in a helicopter rescue, and the miraculous appearance of the aircraft seemed like an angel descending from heaven. The helicopter flew past the clinic, made an abrupt turn, and landed. The pilot shut down the rotors, but left the engine running. He waved impatiently for us to bring the patient. We carried her outside with the help of some trekkers and slid her onto the floor in the back of the helicopter, which immediately took off. We turned our faces away from the dust as the chopper disappeared down the valley, back into the clouds.

It was 3 days before we got word about Barbara. She had arrived in the emergency room at Patan Hospital in Kathmandu an hour and a half after leaving us, having descended 10,000 feet. On arrival at the hospital, she was breathing 18 times per minute and was already responding to pain. Twenty-four hours later, she was sitting up in bed and eating.

Thirty years later, I recognize that the key things I have learned about wilderness medicine were introduced during my experience of caring for Barbara. I was on my own, with no expert to whom I could turn for advice. I had to care for a patient in ways that I had never done in a hospital setting. I had to clean her up, turn her, catheterize her—all by candlelight, in addition to trying to figure out how to medically treat and evacuate her. Although her presentation of HACE remains the most atypical I have ever encountered, I still had to make a diagnosis and act on it, with no further tests or opinions to rely on.

As I reflect back on these events, I still recall the depth of my fear that she would die despite my efforts. I have since witnessed on a number of occasions that this is a not-uncommon feeling among rescuers, who often feel devastated when the person they have tried to rescue ends up dying.

Barbara's illness taught me the value of personal experience. After this episode, the lectures I gave every day that season at the aid post on the prevention of altitude illness carried a sense of personal authority that I could not otherwise have evoked. Symptoms *can* be subtle. Altitude illness really *can* be fatal. Descent really *is* lifesaving.

My career in medicine ran parallel to the development of the field of wilderness medicine. In the mid-1970s, physicians and mountain guides began to meet to discuss what was then called “mountain medicine.” The topics included altitude illness, first aid, frostbite, hypothermia, and evacuation. Lectures and hands-on workshops were included. Gradually the gatherings expanded to include topics of hiking and rafting and the skills that supported those activities, such as water disinfection, treatment of traveler's diarrhea, and heat and cold injury. Because we were no longer talking only about the mountains, this new field was dubbed wilderness medicine. Lecturers shared their anecdotal experiences and opinions, but soon they mined the research literature and carried out investigations of their own. In 1983, the first edition of *Wilderness Medicine* was published. It was also in 1983 that I moved to Kathmandu to begin a 15-year stint working at the CIWEC Clinic Travel Medicine Center and started carrying out my own research into the diseases and injuries that affect travelers in Nepal.

Wilderness Medicine now appears in its sixth edition. Rather than wilderness medicine defining what should be in the textbook, the textbook has helped define what is in the field of wilderness medicine. Instead of focusing solely on traditional areas, the editor has opted for inclusiveness, covering topics that include such stalwarts as lightning and frostbite, but also volcanic eruptions, combat casualty care, alligator and crocodile attacks, global humanitarian medicine, and space travel.

Despite this wide range of knowledge, the specialty of wilderness medicine still has a common denominator: when something bad happens in the field, immediacy and bonding lead to an increased emotional requirement from the rescuers. In addition to diagnosis and treatment of the patient, one is confronted with limited resources and the compounding factors of weather, terrain, and isolation. Not infrequently, rescuers have to place themselves in harm's way. At the very least, they may have to endure their own discomfort and exhaustion. Although these factors create a different dynamic of medical care, ultimately the goal is the same—to ease or prevent suffering in the patient.

The quest for adventure may take travelers to countries with little or no available medical care. Many adventurers think only of *their* personal medical situation or of the risks that *they* are taking in a remote environment. They may give little or no thought to the thousands of people along their routes who can live entire lives without access to even basic medical care. The plight of the world's poorest people may only briefly come to light at those times when a major disaster strikes. Wilderness medicine aficionados have frequently been rescuers in these extreme situations. Their experiences have sometimes taught the physicians what it really means to try to practice medicine on behalf of people who have no resources. They often return with a newly discovered desire to share medical knowledge and skills around the planet on an ongoing basis. They have come to recognize that all human beings are the same in wanting to be happy and free from suffering. Seen in this light, there is no difference between a mountaineer with altitude illness, the traveler with diarrhea, a Tibetan refugee with frostbite, the woman in an African village in the midst of a difficult birth, or a child shivering with the fever of malaria.

My initial attraction to high-altitude medicine had far-reaching consequences in my personal life that I could never have foreseen. After three trekking seasons in the mountains, I moved to Kathmandu, and within a year I had volunteered to be the doctor for a Tibetan Buddhist monastery. The head of the monastery, Chokyi Nyima Rinpoche, became my teacher and close personal friend. By applying his teachings on Buddhist philosophy to my medical practice, I became more the physician I wanted to be—calmer, kinder, clear thinking, and willing to help. Our friendship led to collaboration on a book about how to train in compassion.

I strongly believe that there is a way to connect wilderness medicine to conventional medicine, and even further, to our personal lives. This advice can be condensed into three key principles. First, there is *competence*. We should be advocates of learning and apprenticeship in the backcountry and not be satisfied

with merely attaining just enough fitness to be guided on an adventure. Although one can take pleasure from achieving a distinct goal, one's satisfaction is greatly enhanced by the cultivation of skills gained through lectures, practice in the field, and extensive personal experience.

When one starts to plan a journey or an adventure, one needs to do research and fully understand the limitations imposed by that activity. Are there hazards of weather and terrain that could result in being stranded for long periods? Is there the possibility of rescue? Where is the closest medical care? To what degree are we prepared to accept the situation? *Commitment* means accepting the risks and limitations of a given adventure before facing the challenge, so that one can deal with it realistically. Ideally one would like to avoid having to say, "If I had known it was going to be like this, I would never have gone."

Finally, no matter what happens, one should always make decisions with full consideration of *compassion.* This could involve abandoning one's own goals to help someone else or modifying the trip so that everyone can succeed.

There is a famous Tibetan Buddhist saying that is true in all aspects of our lives, including our wilderness adventures:

All the joy the world contains

Has come through wishing happiness for others.

All the misery the world contains

Has come through wanting pleasure for oneself.

Adventures in the wilderness, by occasionally taking us close to our limits, can teach us a great deal about our true nature. A well-known mountaineer, after living through a major rescue drama on Mt Everest, once said, "The person I wanted to *be* met the person I actually *was*." In such defining moments, I have observed that those who abandoned their own ambitions in order to help others have always ended up happier than those who pursued only their own goals.

The wilderness is a proving ground that draws us in with its physical splendor, then tests us with hardship. We are often changed by these encounters. Whether we perceive these changes as positive or not may depend less on whether we have succeeded in our adventurous goals and more on how we learned to conduct ourselves in pursuit of those goals.

The elderly Sherpa with the head laceration healed without infection and lived for 3 more years, before dying of old age.

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CASE REPORT

They Had Me in Stitches: A Grand Canyon River Guide's Case Report and a Review of Wilderness Wound Management Literature

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We present a case of failed conservative management of a traumatic wound sustained in a wilderness setting. The patient was initially treated with a povidone-iodine scrub, suture closure, and expectant management by 2 physicians who were paying clients on a multiday river rafting expedition. Empiric antibiotic coverage and irrigation of the dehisced wound were initiated several days after initial treatment. The patient arranged his own evacuation 8 days after injury. Hospitalization, intravenous (IV) antibiotics, and surgical debridement with wound vacuum placement led to a full recovery. This case presents several common wound care pitfalls. The sequelae to these pitfalls are more dramatic in a wilderness setting and underscore the importance of early aggressive management and considering prompt evacuation when treating wounds sustained in the wilderness.

Key words: wound management, wilderness medicine, laceration repair, wound infection, prophylactic antibiotics

Introduction

More than 250 million persons visited a national park within the United States in 2012, which meets and exceeds previous attendance records while simultaneously raising the likelihood for potential injuries sustained in wilderness settings.[1] Acute traumatic wounds are common, consistently ranking in the top 10 reasons for emergency room visits for adult males and all pediatric patients under the age of 15.[2] In wilderness settings, lower extremity musculoskeletal trauma has been reported to constitute up to half of all injuries sustained.[3] A comprehensive approach to acute wound care is important in the hospital-based setting, but is especially critical in the wilderness setting, as definitive treatment can be hours to weeks away. The limitation of available medical resources and the variety of acute traumatic wounds present a challenge. Each wound needs individual evaluation to minimize complications of poor wound healing, infection, and long-term functional deficits.

We present a case from the Grand Canyon that illustrates how these factors can come into play with what initially seems like an uncomplicated wound closure and conservative management strategy. The following narrative comes from Brad Dimock, a veteran Grand Canyon river guide for more than 30 years, whose last season sent him to the operating room twice. Brad Dimock is a legend as a Colorado River boatman, one of very few to have rafted the River at almost 100,000 ft^3/s in the infamous Glen Canyon Dam flood of 1983, which was and still is the highest water flow recorded there since early construction work at the Glen Canyon Dam site in 1958.[4] Record-breaking precipitation in 1983 resulted in Lake Powell reaching its highest recorded level in history and the only time the spillways of Glen Canyon Dam have been opened for floodwater management.[5] Brad's knowledge of the Colorado River is encyclopedic. He is also a historian and author of several prize-winning books on rafting and the Colorado River, as well as a publisher and President of Fretwater Press. Dimock's style shies away from pedantic relating of facts as he views every subject as another avenue for his greatest talent, storytelling. This case report is his firsthand account.

Case Report

Day 1 (Day 6 of the trip, but Day 1 of the injury). We are at Bright Angel Trail at Pipe Creek with a big exchange.

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River trips in the Grand Canyon can take from 2.5 to 5 weeks from Lee's Ferry at river mile 0 to South Cove, Lake Mead, at river mile 297 (Figure 1).[6] One can shorten their trip by hiking in or out mid-route, which is called an "exchange." The new passengers have all arrived early, and we are hustling to get things rolling and capitalize on the mileage we can make. I hop onto my raft to grab a water jug and slip off the wet, slippery tube. My foot bounces across a couple of loose duffle bags in my bilge, and my shin slams into the frame. "Ow!" says I, thinking, *That really hurt. This might draw blood.* I pull my leg out and am stunned and horrified to see a 4-inch gash to the shinbone, spreading open, gushing blood. I force the gaping wound closed with my hands and hobble to my seat. It's a big wound; I need help (Figure 2).

We have a quick group discussion to decide who should do the cleansing and Steri-Stripping. The bleeding has stopped, but it is yucky looking. Just as we begin, one of our incoming hikers introduces himself as an orthopedic surgeon and offers to help. His friend, an anesthesiologist, offers a full suture kit with lidocaine (Figure 3). They both feel that stitches are really the way to deal with a wound of this magnitude since Steri-Strips are not likely to hold (Figure 4). I defer to their experience and choose to have them handle the situation. They seem competent, intelligent, and optimistic. Six widely spaced sutures are placed after I had shaved my leg (Figure 5). It is then wrapped up with a 3M Tegaderm transparent waterproof dressing, with a 3M Coban self-adherent wrap to protect it. We all think this looks great and prepare to depart. In all, we don't lose more than a few minutes. There is no dissent on the decision to carry on.

We run the rafts all the way to river mile 104. There we pull the Tegaderm, change to a clean, dry dressing for the night, and celebrate. In the morning, we replenish with a new dry dressing, fresh Tegaderm, and a wrap. This goes on for a couple days and it still looks great. We're all feeling we are doing the right thing.

Night 5. We are 4 days in, and the wound starts looking a little angry and red (Figure 6). The anesthesiologist and orthopedic surgeon start me on trimethoprim/sulfamethoxazole.

Day 6. I rest in the shade while the folks go to Whispering Springs. We still feel like this thing is totally going to be fine.

Day 7. I harbormaster for the day at Havasu Creek and watch the red area on my shin creep past the Sharpie lines we drew around it the night before. A nurse on the trip takes a look at it and cringes diplomatically when I tell him we're probably going to hit it with bigger antibiotics tonight and see what happens. His doubt is contagious and escalates mine. My ankle is a cankle. The wound is heating up. When a finger is pushed into my shin, the dent stays there. I want to talk it over with the docs, but they are at Upper Beaver Falls. I am not panicking, not yet.

The folks get back too late to do an evacuation the same day, and we blast down to a ledge camp at river mile 162. My medical team (the anesthesiologist and orthopedic surgeon) shares my fears. It's beyond what we want to, or should be, dealing with on the river. It's heading south on

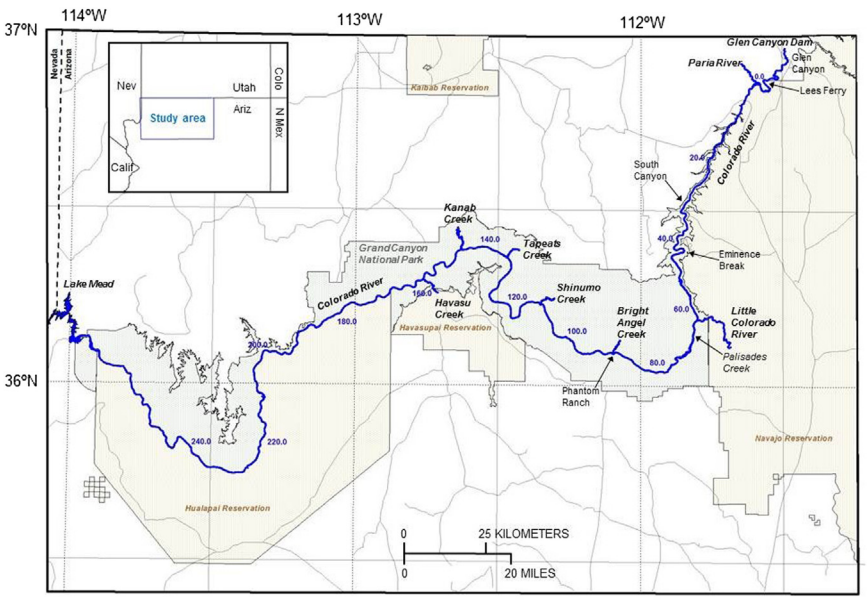

Figure 1. The route of the Colorado River through Grand Canyon National Park.[6]

Figure 2. Initial injury.

us. Since we can't fly at night, they elect to cut stitches, reopen the wound, drain it, wash it, and pack it with povidone-iodine-impregnated gauze. For this surgery, I am instructed to do my own anesthesia—I opt for gin and tonic. GIN and tonic. For douching the wound clean, we use my Flash Gordon squirt gun filled with povidone-iodine solution (Figure 7). It has a far more powerful blast than a syringe. I grimace, laugh, yelp, clench, take pictures, and administer more anesthesia. It's clean now, but I don't even like my steaks to look as cooked as my lower leg does (Figure 8). We begin a second layer of antibiotics, azithromycin, in addition to the trimethoprim/sulfamethoxazole. I feel physically healthy, but the pain and heat in my shin has me terrified. We prepare to launch at first light with the assistants to go find a good southeast window for satellite phone connection and set up the evacuation. All things considered, it's a good plan.

But I toss and turn a lot for much of the night, wretched, scared, and thinking of all the wounds-gone-bad stories I know. The months-in-the-hospital stories. The infection-that-just-won't-stop stories. The loss-of-leg stories. I want to go home really, really bad.

Day 8, 5:35 AM. River mile 163. Contact by satellite phone is made with the National Park Service rangers. A 10:00 AM rendezvous at National helipad is confirmed. I've set up a lot of evacuations in my day, but it's truly weird to be setting up my own. It's a 45-minute helicopter flight to the South Rim of the Grand Canyon with a 1.5-hour drive to Flagstaff from there. At noon I am sitting in a truck with a Big Mac heading for Flagstaff. I enjoy a short-lived optimism.

2 PM. The hospital-based surgeon takes a look, shakes his head, tells me this wound may no longer be closable at this late date, and this may entail a long recovery. The inflammation has reduced a bit, but it looks like hell. I am really, really sad now. It's been a week since I whacked

Figure 3. Numbing the wound with lidocaine.

Figure 4. Suturing the wound in the boat.

my shin, and things are majorly screwed up. At 9 PM I am in the operating room (OR). I awake with a wound-vacuum in place, antibiotics, and a wacky thing around my other calf that periodically inflates and squeezes the fluids from my lower leg like an anaconda that occasionally wakes up, flexes around my leg affectionately, and goes back to sleep.

Day 9. I stare at San Francisco Peak out my window. Nice people come to visit me. The wound vacuum keeps gurgling away, the IV keeps dripping, the anaconda keeps snuggling me.

Day 10, noon. Back to the OR. The tissue is healthy (Figure 9). The wound is closed with new stitches, and I am sent home with antibiotics. Days later I see a very happy shin, no redness, no swelling, no heat, and no cankle below (Figure 10). You have no idea how happy I am.

Discussion

In summary, the presented case is of a healthy male without any known risks for suboptimal wound healing such as smoking, diabetes, or advanced age. His wound was not initially irrigated before closure, but was externally scrubbed with povidone-iodine solution and the leg was shaved. The providers immediately opted for wound closure given the size of the laceration, the personal supplies they had brought, and preexisting expertise with closing wounds in an operative setting. Leaving the wound open was not discussed. The antibiotic choices were made based on the clinical judgment and available resources of the treating providers, and the clinical rationale is not available as the treating field physicians did not coauthor this report. This case brings up the need to have a systematic approach to evaluating injuries and managing the course of wilderness wounds.

Principles of wound management in the wilderness are similar to that of hospital-based management, with the exceptions of evaluating wound appropriateness for closure and often dealing with limited resources for acute wound care.[7] The objectives of this article are to reinforce a systematic approach to wound assessment, review

Figure 5. Final suture repair on day 1.

Figure 6. Wound infection on day 5.

evidence-based common pitfalls in provider care, and apply those lessons to the case reported. This review of the current literature will aid the wilderness medicine provider in maintaining a heightened vigilance for what may initially appear to be a minor or uncomplicated injury.

A 2010 wound management review article reviewed common pitfalls in hospital-based emergency management of wounds.[8] Several errors identified by the authors also impact wilderness wound management. These include failing to provide adequate patient education regarding wound care, use of excessive irrigation (pressure and volume) for clean wounds or for wounds in highly vascularized regions, and irrigation with tissue-toxic solutions such as povidone-iodine, chlorhexidine, or hydrogen peroxide, which can hamper acute wound healing.[9] As seen in this case, 2 competent physicians translated their common practices in the operating suite erroneously to the wilderness setting. Shaving the skin, high-pressure irrigation, and use of povidone-iodine are practical preoperatively for intact skin, but each can be detrimental to wound health in already injured tissue.

Optimal wound management entails appropriate initial irrigation as well as providing a moist wound environment. Occlusive dressings have lower infection rates than conventional dressings,[10] and moist wound environments accelerate wound healing by up to 50% compared with exposure to air.[11] The prehospital providers choose an ideal wound dressing by using a 3M Tegaderm transparent waterproof dressing. This type of wound covering not only keeps a moist environment for optimal wound healing and prevents superinfecting organisms from contaminating the wound, but also allows for visual inspection of the wound without removal because of the transparent nature of the adhesive dressing. However, the treating providers may not have recognized that the wound was contaminated at the moment of insult by the surrounding river water. The only water considered clean, from a wound standpoint, would be water that is potable. This encompasses filtered, boiled, or chemically treated water. Irrigation of wounds with clean water sources can be appropriately managed with manually compressing premanufactured

Figure 7. Wound irrigation on day 7.

Figure 8. Wound immediately after irrigation.

1-L irrigation bottles, or with a 10- to 20-mL syringe depressed to express clean irrigation solution. Research on the effectiveness of improvised irrigation devices has not yet been published.

Freshwater environments are habitats for several Gram-positive species including the coryneform group and *Bacillus* species.[12] Wounds sustained in this setting require Gram-positive antibiotic coverage.[13] Freshwater sources are also a host to many Gram-negative species of bacteria, most notably *Aeromonas,* which is relatively resistant to a wide variety of antimicrobials including trimethoprim, cefazolin, and ampicillin.[12] Although rare, *Aeromonas* colonization is more common with penetrating injuries and also should be suspected in rapidly progressing infections.[14] The majority of freshwater-contaminated wounds respond to oral courses of levofloxacin and trimethoprim/sulfamethoxazole.[14,15] If an *Aeromonas* infection is clinically suggested, one should arrange for prompt initiation of broad-spectrum IV antibiotics and appropriate surgical care.[15] If this wound had been categorized as a "contaminated wound" on initial examination by the treating providers, the commencement of prophylactic antibiotics on the day of injury would have been reflexive.

Uncomplicated wounds less than 2 cm (just under 1 inch) have been shown to have comparable cosmetic and infection rates whether or not sutured closure is used.[16] Clearly this wound was larger, and loose approximation was arguably a reasonable choice. There is a paucity of literature to support a preferred closure technique for wounds sustained in wilderness settings. Tissue glues, either Federal Drug Administration-approved or commercial cyanoacrylate glues, can be used in a relatively safe and efficacious manner in minor trauma.[17] Adhesive strips have been shown to have similar rates of infection, wound dehiscence, and cosmetic results as sutures, but

Figure 9. Wound in the operating room on day 10.

Figure 10. Wound healed (more than 1 year after injury).

have only been systematically compared in small surgical wounds.[18] It is the opinion of the first author that large or high-tension wounds with controlled hemostasis be managed with wet-to-dry dressings and delayed closure. Wounds that require intervention for hemostasis can be sutured, with the provider maintaining a low threshold for evacuation for definitive management. Further study on optimal wound closure in wilderness settings is warranted. The common pitfalls in wound care exemplified by this case stress the point that providers need to dedicate most of their attention to determining whether a wound is truly uncomplicated or not, and then act accordingly given the available resources and the wound environment.

Conclusions

We present a case of a wound sustained in an unclean environment with a delay in empiric antibiotics and evacuation. Providers should consider the potential pitfalls of applying their standard of care routines to wilderness environments, as their knowledge and scope of practice may not translate directly to field practice. Environment-specific microbial considerations as well as limited access to definitive care if wound healing does not proceed as anticipated must be considered in even apparent minor trauma. Wound care principles that were not initially addressed include initial irrigation of the wound and appropriate prophylactic antibiotics at the onset of injury. Further research in wilderness medicine regarding wound appropriateness for closure is warranted.

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