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CASE REPORT

Survival After Being Wedged in a Crevasse for 16 Hours in Alaska

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We present a case of an un-roped mountaineer who fell into a crevasse during descent from the summit of Denali (Mount McKinley). He was wedged about 20 m deep in the crevasse for a total of 16 h; this included 4.5 h waiting for a rescue team to arrive, and an 11.5 h extrication process. His condition deteriorated and he eventually lost consciousness. Even though the rescue team collectively felt there was little or no chance of survival, they continued until the victim was extricated from the crevasse. He was almost immediately placed in a hypothermia wrap with active warming, loaded on a rescue helicopter, and transported for 1 h 40 min to a hospital in Fairbanks, Alaska. During the flight, he was placed on supplemental oxygen. He was cold to the touch; respiration was detectable, but a pulse was not, and he was responsive to verbal stimuli. Initial bladder temperature in hospital was 26.1°C. He was released from hospital after 14 d and made a full recovery. This case highlights an important mix of preventative and resuscitative lessons regarding crevasse rescue in an isolated location. The lessons include the dangers of travelling un-roped on a crevassed glacier, the challenges of extrication from a confined space, the fact that respirations are often more easily detected than pulses, an extended transport time to medical facilities, and the necessity of trying unorthodox extrication methods. This case emphasized the need to continue extrication and treatment efforts for a cold patient even when survival with hypothermia seems impossible.

Keywords: cold exposure, crevasse rescue, insulation, circum-rescue collapse, post-rescue collapse, rescue collapse

Introduction

The main threats to survival for someone who has fallen un-roped into a crevasse are trauma, asphyxiation from inability to expand the chest, and cold exposure.[1] The longest documented survival in a crevasse was 6 d for a victim who fell into a crevasse and sat on the snow at the bottom.[2] In contrast, one victim died from hypothermia after being wedged in a crevasse for only 4 h.[3]

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We present a case of a mountaineer who fell into a crevasse during an un-roped descent from Denali (Mount McKinley) in Alaska. It took about 4.5 h for a rescue team to arrive. His condition gradually deteriorated, and he became unconscious after about 12 h, at which point he was assumed to have died. However, he was extricated 4 h later and fully recovered. This case highlighted the difficulties of crevasse rescue and the importance of continuing extrication efforts even when survival from hypothermia seems impossible.

Case Report

On June 4, 2017, 7 climbers were descending from a successful summit bid on Denali, Alaska. After arriving at Camp 1 on the Kahiltna Glacier (2400 m), a 38-y old

Figure 1. Top: Site of incident on crevassed Kahiltna Glacier (site circled in red). Bottom: Rescue site. Crevasse runs in direction from overturned sled to wands which marked the danger area.

male climber continued to descend un-roped on snowshoes with his partner at about 2330 h (Figure 1, top). About 200 to 300 m from the camp, he stopped near what was marked as a danger spot. He took one step on a snow bridge and broke through into a crevasse (Figure 1, bottom).[4] He fell about 20 m and became wedged between smooth narrowing ice walls which were 18 to 23 cm apart. He was in an upright vertical position with his backpack bunched up at shoulder level. Although he could still breathe, no further movements were possible. Surface air temperature ranged between −7 and −2°C. The top of the crevasse was about 90 cm wide.

The climbing partner returned to Camp 1 to get help. Within 20 to 30 min a mountain guide was lowered to free the victim. With limited specialized equipment, extrication was not possible. A radio call was made to Talkeetna, Alaska for help from the Denali National Park and Preserve mountaineering rangers. Bad weather delayed departure of a helicopter until 0300 h on June 5.

After arriving at about 0400 h, the lead ranger was lowered into the crevasse but could not descend further than about 3 m above the victim. At this point the crevasse was about 25 cm wide. The victim was repeatedly calling out "help, snowshoe," for about 12 h until he became unconscious at about 1130 h. The ranger tried to widen a passage below himself using the adze of his ice axe. Eventually he clipped a rope onto the victim's pack. Rescuers on the surface pulled on the rope until the pack straps broke. After this, the victim could breathe more easily.

At one point, the ranger was having difficulty breathing and yelled to the surface team to pull him up. For a brief period however, the surface team was not directly observing him and did not hear the request. After yelling, the ranger slipped deeper into the crevasse. Because his chest was further constricted, his next attempt to yell for assistance was muted. At this point the surface team noticed the situation and pulled him up so he could breathe.

Meanwhile, rangers in Talkeetna collected several potentially useful tools from a hardware store and had

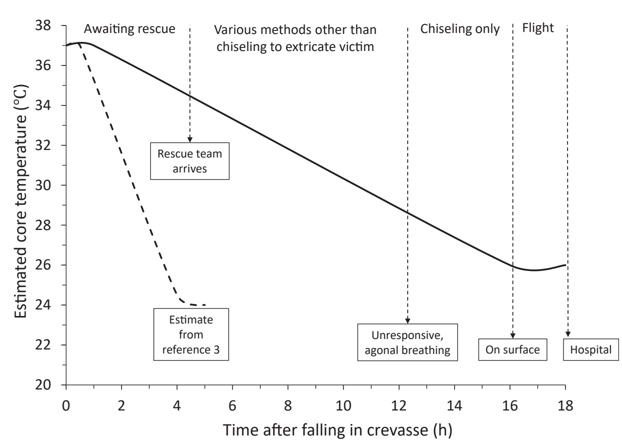

Figure 2. Estimated core temperature (based on symptoms and initial hospital core temperature) for victim during crevasse rescue and flight to the hospital (solid line). The dotted line illustrates a much faster rate of core cooling for a victim who died 4 h after falling into a crevasse in Antarctica.[3]

them flown to the accident site. After 2 h of minimal progress, the rescuers stopped to discuss other options. An attempt to use a chain saw was unsuccessful because there was limited room to maneuver. A blow torch, antifreeze, and even boiling water were used to try to melt the ice with varying levels of success. At this point everyone in the rescue team felt there was no chance that the victim could survive long enough to be rescued successfully. However, they continued their efforts with 1-h shifts of chopping ice with their adzes. They finally reached the victim at about 1200 h. He was unresponsive and had what was described as agonal breathing (Figure 2). Once a rescuer got low enough, he clipped a rope to the harness and the entire surface team pulled on the rope as hard as they could, without moving the victim at all.

At about 1200 h the helicopter delivered a pneumatic hammer-chisel borrowed from the Talkeetna Fire Department and the rescuers started chiseling. At about 1400 h, the victim had been unresponsive for about 2 h and was assumed to be dead. He then briefly gained consciousness, looked around, and lost consciousness again.

After almost 3 h of chiseling, a rescuer was able to reach the snowshoe straps. The limiting factor seemed to be that the snowshoes were wedged in the crevasse. It took about 40 min to cut the straps. For the first time, at 1520 h, the victim moved upward when the rescuers pulled on the rope. They then pulled him to the surface and over the edge of the crevasse at 1535 h. He responded to verbal stimuli, respiration was detectable, but pulse was not. Rescuers immediately brought him into a tent shelter and placed him in a hypothermia wrap. They cut off his wet clothes and sandwiched him between 2 dry chemical heating blankets (Ready Heat II "38x48"; TechTrade, Hoboken, NJ) within a −30°C down sleeping bag. Three 1-L Nalgene water bottles (Rochester, NY) were filled with warm water and placed inside the sleeping bag. He was packaged into a MedTech vacuum spine board (MedTech Sweden Inc, Geneseo, IL) and loaded onto a waiting helicopter that departed at 1541 h.

Because of bad weather in Talkeetna, the helicopter had to make a longer trip (1 h, 40 min vs 30 min to Talkeetna) to the hospital in Fairbanks, Alaska. Although the attending paramedic could not feel a pulse, breathing was detectable, and the victim remained responsive to verbal stimuli. Shivering was never observed. The only in-flight care was supplemental oxygen administered via nasal prongs at a rate of 8-10 $L{\cdot}min^{-1}$. Because of the extended flight, the flow rate was lowered to 3 to 4 $L{\cdot}min^{-1}$; however, both oxygen bottles ran out as the helicopter arrived at Fairbanks at 1723 h.

At 1800 h, his initial bladder temperature was 26.1°C (79°F). Surface warming was achieved via forced-air warming. The patient was admitted to the intensive care unit where he required renal dialysis. After 14 d, he was released and has since resumed climbing.

Discussion

This case provided valuable insights into victim physiology during extended cold exposure and the challenges for responders rescuing and providing medical care in extremely confined spaces.

The victim survived a longer period of exposure than might have been expected when wedged tightly between 2 ice walls.[3] Because he did not sustain any significant traumatic injury, his condition worsened solely from hypothermia. He was initially conscious and coherent. His voice became progressively weaker until he stopped talking after about 12 h. Loss of consciousness probably did not occur at a core temperature >30°C and he likely would not have remained conscious at a core temperature <27 to 28°C (Figure 2). He survived another 4 h in the crevasse and was breathing and responsive to verbal stimuli during almost 2 h of helicopter transport.

The victim was severely hypothermic and at risk of cardiac arrest while being hauled up to the snow surface and during the transfer from the crevasse to the helicopter. At low cardiac temperatures, cardiac arrest can be triggered by rough handling.[5] The fact that a tent and the hypothermia wrap had been set up beforehand increased the likelihood of an efficient, smooth transition.[6] We could not explain the brief period of regaining consciousness and movement at about 1400 h, after 2 h of unconsciousness. This episode should serve as a reminder that the physiological condition of a cold victim may be better than signs and symptoms seem to indicate.

Core temperature at the time of extrication from the crevasse was approximately 26°C (assuming a generally linear cooling rate in the crevasse and an after-drop that was probably reversed during the 1 h 40 min transport) (Figure 2). The core cooling rate was therefore $<1.0°C{\cdot}h^{-1}$. This is much slower than in the case of a helicopter pilot who died soon after extrication after being wedged in a crevasse for only 4 h. His core cooling rate was $>3°C{\cdot}h^{-1}$.[3] In comparison to the mountaineer in the present case, the pilot was older (62 vs 32-y-old), was not wearing cold weather clothing, was probably not as fit, and was in colder air (−14 vs −4°C). Other than these factors, it is not clear why the pilot cooled so much faster.

If a victim can continually speak, it is unlikely that the chest is the main wedge point. If the chest were wedged, each expiration would allow the victim to slide downward to a tighter space until chest expansion would be negligible. This was the experience of the rescuer who needed to be pulled up so he could breathe. If a victim can speak, the wedge point is likely to be an object such as snowshoes, a helmet, or even a backpack. This would help explain why the victim could breathe more easily once the pack was removed. This knowledge may inform strategies for freeing a wedged victim.

The rescue team performed a very difficult rescue in a severely confined space for a protracted period of about 11.5 h. Although they thought the time required for extrication would be far longer than the victim could survive, they kept working even though progress was slow. This emphasizes the necessity to not give up on a cold victim if there are no obvious fatal injuries or signs of death.

Recommendations

This case provided potential lessons regarding rescue/medical operations during extended crevasse rescue. Climbers should always rope up for glacier travel in areas with known or possible crevasses. Surface rescue teams must have at least one person continuously observing any rescuers in the crevasse, preferably with radio contact, in case they need immediate assistance, and an organization that deploys responders to a crevasse rescue should prepare a specific "crevasse rescue and cold kit" that can be immediately loaded onto a helicopter. The Denali National Park and Preserve mountaineering rangers have now created a kit that includes a pneumatic hammer-chisel to aid in extrication, a tripod and winch, and a hypothermia wrap, including a sleeping bag and chemical heat blankets.[6] They have also included an adapter that allows connection of a patient's mask or nasal prongs to the helicopter onboard oxygen supply. Other valuable items could include a mechanical chest compression device, automated external defibrillator, and IV saline with a fluid warmer.

Warm water was placed in rigid bottles for patient warming. Rescuers should confirm that the water will not burn the patient's skin[7] by placing their hand in the water for 10 to 15 s before filling the warming container. Water bags or bladders are recommended over rigid bottles because a greater surface area (almost 50%) can contact the skin.

All search and rescue personnel should be aware of the causes, symptoms, and prevention of rescue collapse (also called circum-rescue collapse).[8] They should be trained with the principle that "the colder the victim is, the more care is required to perform horizontal extrication as gently as possible." Adding a few minutes for gentle handling and to reposition will not significantly increase cold exposure, but will greatly minimize the chance of rescue collapse.[5]

Crevasse rescue training should include techniques for transitioning a victim gently from vertical to a horizontal supine or, for narrower passages, to a lateral decubitus position. Training should also emphasize that, even if a victim must be hauled up in a vertical position, a simple technique using a sling or rope under the knees allows a simple, gentle, and horizontal extrication from the crevasse to the surface.[3]

Conclusion

This case emphasizes the need for rescue teams to pre-plan equipment and procedures specific to crevasse rescue of potentially cold patients. It is critical to continue extrication and treatment efforts for a cold patient even when survival with hypothermia seems impossible. Rescuers should take enough time to ensure the patient is always handled gently and placed in a horizontal position as much, and as soon, as possible to minimize hypotension.

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