LESSONS FROM HISTORY

Bradford Washburn's 1962 NEJM Article "Frostbite: What It Is—How To Prevent It—Emergency Treatment"—Historical Background and Commentary

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Introduction

In the May 10, 1962 issue of *The New England Journal of Medicine*,¹ a rather unique phenomenon occurred: a "Special Article" titled "Frostbite: What It Is—How To Prevent It—Emergency Treatment" was published not by an MD or thermal physiologist, but by a cartographer, Boston native Bradford Washburn (1910–2007). Washburn was then Director of the Museum of Science in Boston. Somewhat more amazingly, the article was originally written for the *American Alpine Journal* (the annual publication of the American Alpine Club), which subsequently gave permission for the *New England Journal* to reprint it. *Frostbite: What It Is—How To Prevent It—Emergency Treatment* was also published as a stand-alone booklet by the Museum of Science in the 1960s, and went through 7 printings by 1978.²

Washburn's article was timely and perhaps even ahead of its time; the treatment of frostbite was then, and continues to be, controversial. Since the publication of Washburn's article, recommendations for frostbite have undergone some important changes. However, the essential tenets that Washburn described in 1962 are still the basis of present-day guidelines. In addition, Washburn included in the article useful practical knowledge and observations on coping with cold weather wilderness and high altitude expeditions.

Washburn was, by 1962, already a legend in North American mountaineering. He had by that time completed 15 major expeditions into the mountains of Alaska and the Yukon Territory of Canada—several of which were undertaken in full winter conditions. His on-going relationship with Mt McKinley (Denali) had resulted in an exquisitely detailed map of the mountain in 1961.

However, for all of his expertise in the Far North, Washburn's most significant early mountaineering experiences took place in the European Alps. As a young man, Washburn was one of the most accomplished American alpinists of his day.³ Perhaps his most notable alpine climb occurred when he was just 19 years old. Washburn achieved the first ascent of the sheer 1400 m north face of the Aiguille Verte near Mont Blanc in the French Alps (accomplished with 2 Chamonix guides). This climb is still considered a fine exploit, even by today's standards.

Regardless of Washburn's mountaineering accomplishments, he is perhaps best remembered as mountain photographer and cartographer. The precision and artistry of his alpine photographic work has placed him in very select company, the likes of which include masters of the craft such as Ansel Adams and Vittorio Sella. As a professional cartographer, Washburn produced the most accurate maps yet accomplished of Denali, the Grand Canyon, the Western Yukon, and Mt Everest. In 1939, shortly after completing his graduate work at Harvard University, Washburn became Director of Boston's Museum of Natural History (later to become the Museum of Science). During his 41 years as Director, the Museum became one of the finest teaching museums in the world under his imaginative leadership and effective administration. To date, 4 published biographies or autobiographies have been dedicated to chronicling Washburn's very full life.^{4–7}

Historical Background

Washburn's medical contributions can be better placed in context after considering some of the noteworthy cold injury-related events that occurred before, and during, his lifetime. In the fall and winter of 1941 to 1942,

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shortly after Washburn had assumed control of Boston's Museum of Natural History on the eve of World War II, the German Army found itself utterly unprepared for the seasonal environmental conditions in the Soviet Union when it invaded and attempted to capture Moscow. This martial effort resulted in the Germans sustaining the greatest number of cold injuries in a single winter ever recorded in military history⁸—over 250,000 cases of frostbite. Until that time, it is likely the troops who survived Napoleon's expeditionary advance on Russia in 1812 held the dubious honor of being witness to and participants in the world's biggest frostbite epidemic. Napoleon's 1812 invasion of Moscow, and his subsequent appalling retreat in the grip of the Russian winter, provided the Surgeon General of the Army, Baron Dominique-Jean Larrey, with ample opportunity to observe the destructive effects of frostbite injury. Larrey wrote a graphic account of the medical aspects of Napoleon's military misadventure.⁹ Terrible cold injury, on top of the disease, malnourishment, dehydration, and general exhaustion of the troops, contributed to a very high death rate in Napoleon's army as it struggled back to France. In a later memoir of the Russian campaign Larrey wrote:

Persons were seen to fall dead at the fires of the bivouacs—those who approached the fires sufficiently near to warm frozen feet and hands were attacked by gangrene The projecting parts of the body, grown insensible or being frozen and remote from the center of circulation, were attacked with gangrene which manifested itself at the same moment, and was developed with such rapidity that its progress was susceptible to the eye—or else the individual was suffocated by a sort of turgescence, that apparently invaded the pulmonary and cerebral systems. The individual perished in a state of asphyxia.¹⁰

Larrey's less-than-scientific observations of the effects of rapid rewarming near open flame convinced him that very slow rewarming (eg, rubbing the affected part with snow) caused the least pain and did the least amount of tissue damage. In a somewhat fantastic, if understandable, leap in logic, Larrey suggested that:

Should these remedies fail [eg, rubbing the affected part with snow], the part ought be plunged in cold water, in which it should be bathed, until bubbles of air are seen to disengage themselves from the congealed part. This is the process, adopted by the Russians, for thawing a fish. If they soak it in warm water, they know from experience, that it will become putrid in a few minutes; whereas, after immersion in cold water, it is as fresh as if it had just been caught.¹⁰

Perhaps not surprisingly, due to Larrey's influence and authority, his suggested treatment for frostbite was ac-

cepted practice well into the 20th century. Even as late as 1942, the well-known British Himalayan mountaineer and physician Raymond Greene—who participated in the first ascent of Kamet (7756 m, in the Indian Himalaya) in 1931 and an early attempt on Everest in 1933—wrote in the *Lancet* that frostbitten parts should be kept cool and that only slow natural warming should be permitted without the addition of any external heat.¹¹

Unknown to Greene and western medical science at this time, however, investigators at the Kirov Institute in Russia had begun a series of experimental studies examining frostbite treatment in the decade prior to World War II.¹² In the course of testing a variety of rewarming methods, they found that rapid rewarming of the frozen body part in water provided improved treatment results compared to slow rewarming. Unfortunately for the Soviet troops during World War II, rapid rewarming was not practiced on any sort of wide-scale basis. The heating of water simply to provide hot drinks or soup was itself a major logistical issue in combat conditions. Moreover, these Soviet findings did not make their way to the West until after the Second World War.

An escalation in Western frostbite research was prompted by the fears of the NATO-Soviet Cold War turning hot and the concern that Western armies might, once again, be fighting a large-scale war in the plains and mountains of central Europe (and elsewhere). By the early 1950s, the NATO medical handbook had adopted rapid rewarming in warm water as the treatment of choice for frostbite injury. From the early 1950s until the early 1980s, basic research into the pathophysiology of frostbite was intense,¹³ and the first (published) major clinical experience with rapid rewarming was a report out of Alaska in 1960¹⁴—which happened to be the vanguard of a series of important papers by Alaskan clinician-investigators (the series of 3 1960 to 1961 articles),^{14–16} which were later reprinted.¹⁷ Washburn's 1962 *New England Journal* review would not have been as important as it was nor had the impact it did without the original work of Mills, Whaley, and Fish published 2 years earlier. When considering the clinical highlights of the 1960 Mills, Whaley, and Fish article,¹⁴ it is clear that major recognition is due their work for the proposal of:

. . . [A] total-care system approach, including the avoidance of trauma to the frozen extremity, and rapid rearming in warm water (preferably in a whirlpool bath). Postthaw whirlpool [should be] utilized to massage tissue, promote circulation, and dilute the superficial accumulation of bacteria and thus discourage infection. Isotope and enzyme studies were utilized to determine circulatory status, and for early diagnosis of extent of injury.¹³

Mills, Whaley, and Fish¹⁴ also noted the lethality to affected tissue of the second freezing episode in freeze-thaw-refreeze injury, and they suggested the time-honored description of first- through fourth-degree frostbite be changed to a more descriptive clinical diagnosis of “superficial” and “deep,” which is still favored by many authorities today as “mild” and “severe.”

Are Washburn’s 1962 recommendations still relevant?

Given Washburn’s practical experience with living and working in high and cold environments, it is perhaps not surprising that he discussed dietary considerations as well as frostbite:

... [T]he great importance of an adequate diet for the production of body heat at all altitudes. Cold weather definitely increases caloric needs, and variations in diet can have equally definite effects on tolerance of cold.¹

Washburn was an ardent believer in prevention as well as treatment of frostbite: “Most of the time frostbite can be prevented by experienced leadership, good physical condition and adequate food and equipment, intelligently used.”¹ From his own practical experience, he was keenly aware that the first line of prevention of cold injury was proper clothing and equipment along with an adequate supply of food for thermogenesis. He was also aware that the most important fundamental consideration regarding fueling heavy physical work in the cold or in combination of cold and altitude is, as Washburn put it, “plenty of good food” “Good food” that is appetizing and served warm is likely to be consumed and therefore subsequently beneficial. Washburn commented upon the best source of calories during cold weather excursions, and was one of the first to clearly distinguish between diets for work in the cold at sea level vs diets for work in the cold at altitude.¹ He stated that diets consisting of high levels of fat can be tolerated well by individuals doing heavy exercise in extreme cold environments at low altitude whereas dietary carbohydrate becomes particularly more critical as altitude increases above 10,000 ft. Washburn was a contemporary of fellow scientist/mountaineer LGH Pugh and was apparently in close agreement with Pugh¹⁸ on the anecdotal benefits of carbohydrate in the diet of climbers; it was not until 7 years after Washburn’s 1962 comments on carbohydrate that observations would be published by Consolazio et al.¹⁹ identifying carbohydrate as an important factor in lessening the initial severity of altitude illness.²⁰

Because Washburn’s article was originally aimed at mountaineers operating in a cold, high-altitude setting, his overview of frostbite and recommendations for treatment tended to have a very practical orientation for those in field environments. When describing basic differences

between superficial and deep frostbite, for instance, he mentions that accurate prognosis of the extent of injury is often impossible immediately after the initial damage has been done and “time alone will reveal in retrospect the kind of frostbite that has been present.” This point of watchful waiting—discouraging hasty surgical procedures—needed to be emphasized rather strongly in 1962, and Washburn stressed that:

[s]urgical intervention is rarely needed in less than two months [provided proper wound care is exercised and no infection occurs] Under normal circumstances in an extreme case in which loss of some tissue is inevitable, despite careful treatment, the necrotic material will simply slough off at the proper point and the proper time, with a maximum saving of the sound underlying tissue.¹

Treatment recommendations of 1962 are perhaps the most interesting aspects of the *New England Journal* review article to examine in light of state-of-the-art present-day advice. The aforementioned series of 1960 to 1961 articles by Mills and his Alaskan colleagues^{14–16} were fundamentally (and clearly) responsible for a paradigm shift in frostbite treatment, and these papers must have, in large part, provided the impetus for Washburn to write his review in the first place. First and foremost, Washburn emphasizes that rewarming of frozen extremities should be delayed until the patient is in an environment where refreezing will not occur. It was rightly recognized that rewarming followed by refreezing could cause extensive damage—this had been observed, if not fully understood, at least as far back as Larrey’s time. Furthermore, Washburn made a strong point of recommending no ambulation on thawed feet or toes, as this would likely greatly exacerbate any damage already suffered. In fact, a rather convincing personal communication with the era’s leading frostbite expert, WJ Mills—commenting on freezing injury sustained on the high, cold peaks of Alaska—is quoted in Washburn’s *New England Journal* article:

Unless you have an adequate method for transporting the patient down, either by helicopter or by sled so that he himself need not use his hands or feet, I think I would discourage thawing at 18,000 ft [H]e would be wise to stump his way down with frozen, unthawed feet even if it took 12–18 hours, as long as the objective was adequate shelter, reasonable comfort and a spot from which he could be flown or carried to a hospital. We have had a half dozen patients who have walked for three or four days with completely frozen extremities—some of whom have sustained no loss at all. Others lost toes only. In no case did any of them lose any more of the foot than toes. There appears to be an opportunity even to preserve all of the digits, provided that as soon as the patient reaches a place

where thawing can be managed, it is done by the method of rapid rewarming, followed by the regular routine of aseptic hospital care.¹

Washburn's suggestion for thawing frozen extremities involved the use of a "large vessel of water" warmed to 42 to 44°C. Current guidelines submitted for publication in this journal suggest a slightly cooler temperature, 37 to 39°C.²¹ Likewise, pain relief recommendations during the rewarming process have not altered dramatically over a span of almost 50 years. Where Washburn suggested a standard dose of acetylsalicylic acid tablets and "if the patient is in good condition" (ostensibly concerned about respiratory depression given his reasoning) the addition of 25 mg meperidine, current recommendations suggest giving pain medications as needed (typically NSAIDs or opiate analgesics).²¹ However, the 1962 *New England Journal* article's recognition of frostbite treatment success depending largely on 2 factors still holds true today:

The exercise of extreme care during and after rewarming, so that the delicate injured part is not further damaged . . . [and] the prevention of infection, which becomes the paramount issue from the time of rewarming to the conclusion of the treatment.¹

In fact, the Wilderness Medical Society (WMS) Consensus Guidelines for the Prevention and Treatment of Frostbite²¹ state: "Protection of the frozen tissue should be undertaken to prevent further trauma. If at all possible, a frozen extremity should not be used for walking, climbing, or other maneuvers until definitive care is reached."

In the discussion of postthaw hospital treatment in Washburn's *New England Journal* article, it becomes obvious that theory and practice of frostbite injury therapy has, in many respects, made appreciable (if not always scientifically convincing) progress over the course of a half-century. For example, Washburn points out that one of the key hospital treatments in 1962 was 1 or 2 whirlpool baths daily for the affected extremity or extremities. Modalities such as whirlpool bath therapy may be helpful, but research experience since Washburn's time has not definitively demonstrated that it improves outcomes.²¹ We are now cautiously optimistic about what other possible therapies may ultimately be added to the list of recommended treatment options—such as hyperbaric oxygen therapy and thrombolysis.²¹ Even so, while anecdotal success of frostbite treatment with hyperbaric oxygen therapy has been shown, controlled studies have yet to be conducted in this patient population. Thrombolysis has emerged as a potential significant treatment, but only for deep and recent frostbite injuries without exclusion criteria. Surgical sympathectomy has been used to treat long-term pain, paresthesias, and numbness that may develop in frostbite patients. Conflicting study results and unreliable outcomes have limited

sympathectomy therapy, however.²¹ It is still recommended that surgical amputation for frostbite injury be delayed from several weeks to several months to allow for demarcation of tissue necrosis as suggested by Washburn in 1962. However, improved medical technology now offers bone scans, magnetic resonance imaging, and angiography that can assist in determining surgical margins between viable and nonviable tissue.

Conclusion

Washburn's practical 1962 review of frostbite and its treatment highlighted the ground-breaking original work from Mills, Whaley, and Fish^{14–16} that emerged from Alaska in the immediate years prior to the *New England Journal* article. We have compared and contrasted selected aspects of the state-of-the-art recommendations from that era with today's up-to-date recommendations as reviewed in the "WMS Consensus Guidelines for the Prevention and Treatment of Frostbite."²¹ Most of Washburn's injury descriptions and suggestions for prevention of frostbite are as relevant today as they were 50 years ago. Treatment recommendations have undergone some important (though not necessarily numerous) changes, largely because of a better understanding of the pathophysiology of frostbite and leaps in technological advancement. However, the basis of present-day guidelines are easily recognizable in Brad Washburn's extremely practical article—which, incidentally, was probably the first, and will likely be the last, article from the journal of a mountaineering club that will be reprinted by the *New England Journal of Medicine*!

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