LESSONS FROM HISTORY

Extreme Altitude: Words From on High

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Medical science has its own objective language for describing the effects of high altitude. Mountaineers' words and metaphors tell the story with subjectivity and feeling. This essay will include only limited physiology about lowlanders and high altitude. Instead, the focus will be literary, using the quotations of 20th-century mountaineers and mountaineer physicians to provide color commentary about the hardship. These are Words From on High.

Key Words: altitude, mountaineering, literature, quotations, Himalaya, Everest

Introduction

Medical science has its own objective language for describing the effects of high altitude. Mountaineers' words and metaphors tell the story with subjectivity and feeling. Many of the Words From on High quotations in this essay are from the penultimate risk area in the Himalaya where "all places above 8,000 meters (26,246 feet) belong to the dead."^{1(p20)}

This essay will include only limited physiology about lowlanders and high altitude, acute mountain sickness (AMS), decreased exercise capacity at altitude, high altitude pulmonary edema (HAPE), high altitude cerebral edema (HACE), the Death Zone, and high altitude deterioration. Instead, the focus will be literary using the quotations of 20th-century mountaineers and mountaineer physicians to provide color commentary about the hardship in these categories.

HIGH ALTITUDE AND AMS

High altitude may be defined as 2440 m (8000 feet), with extreme high altitude at greater than 5490 m (18,000 feet).^{2(pp4–5)} High altitude illnesses occur at or even below the lowest of those levels, beginning with AMS, a constellation of symptoms including headache, malaise, nausea, and difficulty sleeping. AMS and its complications are often diagnosed by the Lake Louise Score,³ and much of the physiology in this essay is summarized from the text of West et al.⁴ The *sine qua*

non of AMS is headache, probably related to early cerebral edema whose much rarer end point is HACE. Severe headache stops many hikers and mountaineers. American John Roskelley on Nanda Devi complained that "[e]very muscle was throbbing, especially the one between my ears."^{5(p81)}

Abnormal breathing at night persists with further ascent, even in the acclimatized.^{4(pp202–215)} Lowland sleepers at high altitude have poor-quality sleep and a central sleep disturbance with instability in the feedback systems that control ventilation. Canadian surveyor E. O. Wheeler in Tibet on the 1921 British Expedition to Everest describes it this way: "I find that I am on the point of dropping to sleep...when I seem to hold my breath and wake up gasping."^{6(p267)} British 1930s Himalayan veteran and prolific writer Frank Smythe is his usual dramatic self here, exaggerating for his lay audience: "Cheyne-Stokes breathing is experienced by those who climb high....The fact that at lower levels it is only seen in dying persons is proof in itself of the borderline conditions on Everest."^{7(p613)} Periodic breathing at high altitude was well known to both mountaineers and scientists by then, but the average reader would have only been familiar with oscillatory or agonal breathing patterns in terminal illnesses. On the other hand, Smythe may not have been overstating. He was familiar with the highest altitudes, where severe hypoxemia with nighttime apneic spells is impressive, and the rule "climb high, sleep low" is wise. Smythe wisecracks that "[t]o sleep well at high altitudes a man must be very tired."^{7(p584)}

Altitude acclimatization is a physiological process involving respiratory, circulatory, hematologic, metabolic,

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and other changes whereby the body partially adjusts to reduced partial pressure of oxygen, but there is variable individual susceptibility, response, allowable ascent rate, and limit. Only previous experience is a useful indicator of who is at risk. British Himalayan explorer Eric Shipton notes that “[o]ne man acclimatises quickly, another slowly....The whole process appears to be analogous to sea-sickness about which predictions are impossible.”^{8(p376)} Like acclimatization, deacclimatization is variable as well. One rule of thumb is that after descent it takes about as long to lose acclimatization as it does to gain it, but some individuals have more “carryover” than that, anecdotally perhaps several weeks.^{2(p230),4(p62)} The other half of the Shipton-Tilman explorer duo, H. W. Tilman, stretches it wildly to 3 years on his Kilimanjaro climb: “I was beginning to feel the effects of altitude...but it was very noticeable that these symptoms were not nearly so well marked as in 1930, substantiating the well-known fact that acclimatization is retained to a certain degree over long periods.”^{9(p103)} More likely, he benefitted from different conditions and improved recognition and management at high altitude, including pace, workload, and hydration.

DECREASED EXERCISE CAPACITY

Aerobic exercise capacity decreases as altitude increases and differs from the more protracted condition of high altitude deterioration. Even with acclimatization and despite strikingly greater ventilation, lowlanders can only partially improve to submaximal exercise levels and endurance compared with their own performance at sea level.^{4(pp164–184)} Even simple activities become arduous, especially at great altitudes. The following quotations may reflect a combination of many factors, including both decreased exercise capacity and deterioration, about which more will be said later. Here is Tilman again: “I had mountaineer’s foot—inability at times to put one in front of the other.”^{10(p525)} Joe Tasker, who with Pete Boardman disappeared on the Northeast Ridge of Everest in 1982, portrays the suffering: “It was as if we were runners on a race track we knew with a ball and chain on each foot,”^{11(p23)} and he gauges that “[a] load of 30 lbs is crippling above 20,000 feet.”^{12(p66)} At the top of Everest, with acclimatization but without supplementation, maximal oxygen uptake of only 1 L/min is so low, just above the basal metabolic rate, that a climber uses it for muscles to breathe and to stay warm, with only little left over for ambulation, or thinking.

HIGH ALTITUDE PULMONARY EDEMA

High altitude pulmonary edema (HAPE) is a life-threatening form of noncardiogenic pulmonary edema occurring in otherwise healthy people at high altitude

with individual predisposition, cold, workload, and other factors contributing. Historical landmarks of the modern era include a 1960 HAPE case report¹³ by Charles Houston, MD, mountaineer and author of K2 fame and Operation Everest hypobaric chamber studies. In the same year, Herb Hultgren, MD of Stanford reported even more cases of HAPE¹⁴ and in 1964 gave catheterization results from his South American studies,¹⁵ thus helping define the circulatory dynamics of HAPE and advancing the still-accepted pathophysiology of hypoxia-induced inhomogeneous pulmonary artery precapillary constriction and hypertension, with overperfusion of lesser-affected segments causing pulmonary capillary leakage and edema.^{16,17}

Tasker applies some British understatement in *Savage Arena*: “Apart from the difficulty of performing any action with such a low oxygen intake, there is also an unquantifiable risk of contracting pulmonary or cerebral oedema, the sickness of high altitude which fills the lungs or brain with fluids. This, at best, is incapacitating and at worst is fatal.”^{11(p179)} Neurologist Charles Clarke, MBBCh, in *Everest the Hard Way* in 1976 recognizes that “‘[d]isproportionately breathless’ is the key to it all....Clearly, he was in incipient pulmonary edema....Slowly, it became abundantly obvious that he must go down.”^{18(p92)} The diagnosis was not so obvious in previous times. Here is Physician Raymond Greene, MBBCh, in 1974 looking back to Everest in 1933: “My diagnosis then was pneumonia, but now, forty years later, I realize that he had the mysterious disease of great altitude we call acute pulmonary oedema. I gave him oxygen all night and the next day sent him down.”^{19(p146)}

HIGH ALTITUDE CEREBRAL EDEMA

High altitude cerebral edema (HACE) is usually associated with even higher and longer stays. It is perhaps the end point of unbridled AMS and is immediately life-threatening. Incompletely understood, HACE is a vasogenic and cytotoxic brain swelling that usually occurs in the setting of AMS or HAPE.^{4(p300),20} Presentation may be initially subtle, with ataxia and mental status changes dominating, but unconsciousness can follow rapidly in just hours.

The central nervous system is exquisitely sensitive to hypoxia, with or without edema. The authors here and the next section probably had dull brains from “only” simple hypoxia or hypothermia and exhaustion. Then again, many climbers have come down stumbling and mumbling, thus meeting the ataxia and altered mental status criterion for at least early HACE. In severe HACE, once coma has developed, death is much more likely,²⁰

so there are no quotations from those victims and few from the rescued survivors who may remember little. Shipton testifies that “[a] climber on the upper part of Everest is like a sick man climbing in a dream.”^{21(p487)} Critically ill and mentally deranged would not be too strong an interpretation. Russian Anatoli Boukreev on the Lhotse Face sounds clinical: “The earliest symptoms of HACE and HAPE, for even the most experienced climber, can be confused with the usual discomforts of acclimatization, and a misunderstanding can be fatal.”^{22(p78)} Boardman in *Sacred Summits* is more succinct: “At high altitude there are few clues in the survival game, and it is important not to miss them.”^{23(p213)} Fortunately, even in these dire straits, there are some survivors and some levity, this by 1953 Everest leader John Hunt about Noyce and Band when some of his party turned back: “He actually dropped into sort of a stupor several times on the move, and during a pause for rest and food, Wilfrid found him asleep with a sardine hanging out of his mouth—and George is fond of sardines.”^{24(p156)}

There is not enough space here to fully discuss a favorite in the mountaineering literature, hypoxia-induced hallucinations, but there have been subtle ones, frank ones, and a famous Frank Smythe one high on Everest in 1933 when he handed a Kendal Mint Cake to an imaginary companion.^{7(p633)} Others felt they were in a time warp. Austrian Kurt Diemberger: “You forget about time. It is as if the whole dimension ceases to exist up here.”^{25(p519)} American Conrad Anker, who found George Mallory’s body on Everest in 1999, clocks in: “Altitude confuses your sense of time. You think you’ve been doing something for fifteen minutes, but you’ve been doing it for an hour. A metaphor occurred to me after my experience this year on Everest. At altitude, it’s as if there’s a house burning, and the house that’s burning is you, but everything’s happening at such a dragged-out pace you can’t do anything about it. You just watch the house burn down.”^{26(p17)}

THE DEATH ZONE

Fully acclimatized individuals who sojourn to the highest altitudes without supplemental oxygen are physiologically capable of limited stays of only days, weeks, or a few months but in the Death Zone usually just a few hours or days, if at all. The record may be a stormbound 10 days by Willi Bauer on K2.^{27(p195)} The Death Zone was coined by the Swiss radiologist and 1952 Everest leader Edouard Wyss-Dunant, MD, designating stages of the *Todeszone*^{28(pp110–117)} at 7800 m and 8600 m. Today we round it off, coinciding with the 14 peaks of over 8000 m, near the limit of short-term survival.

Smythe sets the comfort limit to below the Death Zone, 26,246 feet in English measure: “Himalayan mountaineering is one continuous round of hardship and discomfort...if he would enjoy himself, the Himalayan mountaineer should limit himself to peaks less than 23,000 feet.”^{29(p488)} In 1975 Dougal Haston, the Scot, and Doug Scott, the Englishman, became the first actual British Islanders to reach the summit of Everest. Haston decreed that “[t]here isn’t really such a thing as a rest day at 24,000 feet.”^{30(p130)} Most modern Everest climbers sleep or climb with oxygen at or above that altitude, according to one current chronicler.³¹

Peter Lloyd was a veteran Himalayan climber and oxygen engineer when the British finally succeeded on the south side of Everest in 1953. He omits the serious technical climbing obstacles on the north side, but quips about life’s borderland solely from an oxygen standpoint: “Were it 1,000 feet lower, it would have been climbed in 1924. Were it 1,000 higher, it would have been an engineering problem.”^{32(p234)} Smythe also chimes in about that last thousand: “Everest...is exacting on the mind as it is on the body. Those who tread its last 1,000 feet tread the physical limits of the world,”^{33(p207)} and “[w]e stood on the very boundary of life and death.”^{7(p622)} Of all the factors affecting the oxygen cascade down to the mitochondria, barometric pressure is first and foremost. The air is so thin there that a storm or even diurnal variation is enough to tip the delicate balance. “More than two-thirds of the earth’s atmosphere lies below its summit, and for an unacclimatized man without oxygen, the top of the mountain is more endurable than outer space by only two or three minutes.”^{34(p5)} That last assertion was no exaggeration in William Siri’s introduction to *Everest: The West Ridge* about the 1963 outrageously dangerous first traverse of an 8000-m peak by Tom Hornbein and Willi Unsoeld, the former proclaiming *in extremis* up high that “[d]eath had no meaning, nor, for that matter, did life.”^{34(p175)} Hornbein sounded fatalistic because of his body being so physically exposed as well as his brain being out on a hypoxic limb. Tasker had already half-joked in *Everest The Cruel Way* that “[w]ithout sufficient oxygen...[m]y mind was as active as a garden snail,”^{12(p71)} and before that, Wilfrid Noyce announced with anatomical accuracy that “[t]he top layers of my brain were probably dormant up there...[but even more dangerously] I thought I was as alert as at sea level.”^{35(p237)} Such loss of executive function in this setting can lead to bad judgment and disaster.

Shipton recalls that “[w]e experienced the well-remembered feeling of helplessness, of being only half alive.”^{8(p431)} Tyrolean Reinhold Messner on Nanga Parbat admits to not having enough brains to comprehend even

that much of it: “We had been up in the Death Zone for hours now, walking the fine line between survival and dying. We were not really conscious of being in a life-threatening situation.”^{36(p204)} His brother and climbing companion Gunther was never seen again. Messner went on to be the first person to successfully summit all fourteen 8000-m peaks without bottled oxygen. While soloing high on the north side of Everest in 1980 he depicted the severity: “Breathing is so strenuous that no power to think remains....I am like a walking corpse.”^{37(p214,231)}

An Everest guidebook, by Dutchman Harry Kikstra, not just a writer but a Seven-Summiteer, reminds us that “[e]very day you feel bad, and the moment you feel a bit better, you move higher and start feeling bad again. You are surrounded by sick people, and climbers whom you met only last week die climbing. Simple tasks become onerous, and the expedition becomes an odyssey with a possible fatal outcome. Most of the time, climbing Everest is no fun.”^{38(p32)} Messner, too, wrote, “High-altitude mountaineering is not a pleasure; it is a total misery.”^{36(p129)} Raymond Greene did not quite make it up to the Death Zone on Everest in 1933 but was close enough to add some dark humor: “I was a sick man....I had no wife or children for whom I could feel responsible: my parents have five other children and, though I knew they would mourn, they would lose only a small proportion of their offspring.”^{19(p160)}

HIGH ALTITUDE DETERIORATION

High altitude deterioration was known, if not understood, to early Himalayan explorers in part because they were often at altitude far longer than modern climbers. Deterioration begins about where atmospheric pressure is roughly half of normal, advances dramatically faster as one goes higher, and even with adequate warmth, hydration, and nutrition it inexorably outstrips acclimatization.^{4(p63),39} The 1960–61 Silver Hut Expedition suggested that the loss of weight, muscle wasting, and other physical and mental deterioration at 5800 m exceeded the maximum altitude for permanent residence. The science leader was L. Griffith C.E. Pugh, whose comprehensive biography, *Everest: The First Ascent. How a Champion of Science Helped to Conquer the Mountain*,⁴⁰ won the 2013 prestigious Boardman-Tasker and Banff Mountain Festival prizes for mountain literature. One of the other physiologists at the Silver Hut, John West, later archived the Pugh papers at the University of California San Diego and continues a lifetime of authoritative work.⁴ What follows are deterioration-related quotations about fatigue, muscle wasting, and mental lethargy from being up high for many weeks or months.

About fatigue, first is Mallory: “The ultimate limit would be determined, not by a man’s capacity when starting fresh on a single day, but when starting on the last of several days after using up the reserves of strength by successive efforts above 21,000 feet; for the reserves are not made good by a night’s rest at these great heights.”⁴¹ Next is Smythe: “Anyone who makes a severe physical effort over 22,000 feet has to pay for it afterwards,”^{7(p589)} and then Shipton: “‘Desperate efforts’ are not made above 22,000 feet without great exhaustion, from which it is not possible wholly to recover without a prolonged rest at a very much lower altitude.”^{8(p372)}

On muscle wasting, Shipton wrote, “It was like a wasting disease, causing rapid degeneration of our muscles and progressive weakness and lethargy.”^{42(p78)} Then 1933 British Everest leader Hugh Ruttledge: “[A] great deal of wasting occurs as a result of prolonged residence at high altitudes.”^{43(p225)} Raymond Greene on that same expedition is shocked: “I took off my clothes for the first time in six weeks and had my first bath. I was horrified by the wasted muscles.”^{19(p164)} Boardman a few decades later is concise once more: “We had left a lot of muscle on the mountain.”^{23(p166)} Bentley Beetham, on the 1924 expedition that lost Mallory and Irvine, is actually not so theatrical as it seems here: “The last reserves had been used up long ago, and our limbs would have moved a cannibal chief to tears.”^{44(p159)}

About mental lethargy, Hunt on the South Col in 1953 warns of its consequences: “There was a great urge to do nothing—the danger sign of deterioration.”^{24(p187)} In *Snow in the Kingdom*, Ed Webster lost fingers to frostbite and identified that “[w]e’d been distilled into two groups: one totally dedicated to reaching Everest’s summit, and the other, burned out, ragged, finished, their sole desire to find a warm beach or to fly home.”^{45(p90)} Sometimes, there is only one group, answers Charlie Houston in *K2: The Savage Mountain*: “Not one of us but wished the job were done: not one of us but longed for Base Camp and for home. Apathy grows strong on high peaks, the body become feeble, the force to advance declines.”^{46(p160)} The same was noticed by the Swiss; here is Raymond Lambert on Gaurisankar and Cho Oyu: “I was surprised to see how enfeebled the expedition was becoming....Our companions were no longer putting up a fight; they could hardly struggle against the cold and were letting death creep upon them without striking a blow to defend themselves. This was the usual ill-effect of altitude.”^{47(p148)} Timing is everything, the proverbial math formula of the bathtub filling and draining, acclimatization improving while deterioration advancing.

Conclusions

Modern climbers' experiences and writing may benefit from better transportation, elaborate basecamps, lightweight oxygen and gear, weather satellite imagery, and proper acclimatization followed by alpine ascents instead of being worn down by siege-style climbs, and more. To this writer, the misery of the high altitude pioneers tells the story better, both in terms of mountain literature and illustration of some of the high altitude illnesses and physiology.

Perhaps a final statement in this essay deserves an Eric Shipton thought, smooth, accurate, and to the point: "At altitudes of 25,000 feet and beyond, the effects of low atmospheric pressure upon the human body are so severe that...the consequences of even a mild storm may be deadly, that nothing but the most perfect conditions of weather and snow offers the slightest chance of success, and on the last lap of the climb no party is in a position to choose its day."⁸(p434)

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