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LESSONS FROM HISTORY

Snow Blindness and Other Eye Problems During the Heroic Age of Antarctic Exploration

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During the heroic age of Antarctic exploration, snow blindness was a common problem, but not all the descriptions of it fit the modern view of the disease, and some of the explorers complained of long-term problems. This article describes the snow blindness and other eye problems that occurred during this era. It also describes how snow blindness was prevented and treated.

Key words: snow blindness, expedition medicine, Antarctic, history of medicine

Introduction

The heroic age of Antarctic exploration started with the declaration by the Sixth International Geographical Congress in 1895 "[t]hat the exploration of the Antarctic Regions is the greatest piece of geographical exploration still to be undertaken . . . [and] that this work should be undertaken before the close of the century."[1] It ended with the death of Sir Ernest Shackleton in 1922. Much has been written about the expeditions of Robert Scott, Roald Amundsen, and Ernest Shackleton, but there were at least 18 expeditions to the Antarctic during this time. Alexander Macklin (one of Shackleton's surgeons) said that the main problems faced by the expeditions were "[s]curvy (and allied conditions), frost-bite and snow-blindness. Sea-sickness is a fourth condition which may cause disability."[2] Every book and report mentions snow blindness, but the descriptions do not always fit the modern view of the condition. In this article, I describe snow blindness, as it was described at the time, and the other eye problems that occurred in this remote environment.

Snow Blindness

Snow blindness is an acute conjunctivitis and superficial epithelial keratitis caused by exposure to ultraviolet light or what Ernest Shackleton described as "the violet rays."[3] It occurs because ultraviolet exposure is increased by the light reflecting from the snow. Ultraviolet exposure will also be higher at altitude (eg, on the Antarctic plateau) and with clear skies. Exposure to ultraviolet light will be greater on bright sunny days, and Edward Atkinson, the senior surgeon on Scott's *Terra Nova* expedition (1910–1913) says that "[f]ifteen minutes of such a day will cause snow-blindness."[4] The symptoms were described (to a lay readership) by Macklin as "a condition of acute and sudden congestion of the eyes, affecting chiefly the conjunctivae. . . . The little blood-vessels become dilated, producing a prickly sensation of grit in the eyes, which become painful in strong light. The condition may become worse, leading to a marked congestion with heavy discharge and total blindness."[2] These symptoms are clearly describing snow blindness, but some of the symptoms described are not typical of what is now described as photokeratoconjunctivitis, and there are other possible causes of some of the eye problems.

All authors seem to agree that snow blindness was worse in diffuse light. Macklin said that "[s]now-blindness is produced less frequently by sun-glare on the snow than by a diffuse dull light which casts no shadows and requires continuous strain to pick out hummocks and unevenness of the ice."[2] Roald Amundsen also complained, "When I became snow-blind it was cloudy so it is not only the sunlight on the ice that can make you snow blind."[5(p179)]

Cloudy days in Antarctica cause particular problems, with no shadows, no contrast, and difficulty in distinguishing between the sky and the snow. Amundsen wrote, "This grey haze, presumably a younger sister of

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fog, is extremely disagreeable. One can never be certain of one's surroundings. There are no shadows; everything looks the same. In a light like this . . . [one] does not see the inequalities of the ground until too late until he is right on them. This often ends in a fall, or in desperate efforts to keep on his feet. . . . . This light is also very trying to the eyes, and one often hears of snow-blindness after such a day."[6(pp214,215)]

Atkinson described two types of snow blindness. Classical snow blindness was caused by "[s]elective reflection of violet and ultra-violet rays from the sun at maximal elevation . . . the symptoms being photophobia, lacrymation, chemosis with slight hyperaemia of the retina, and later small corneal ulcers. The symptoms come on rapidly, especially on entering a tent where a [P]rimus stove is burning." However, the snow blindness occurring on dull days was different. Ultraviolet light played some role, "but in addition, a diplopia lasting several days occurs. This is probably due to tiring of the internal and external ocular muscles, and is caused by difficulties of vision through lack of contrast. Lachrymation, photophobia, and chemosis are less marked and there are no retinal changes."[7] Macklin agreed that "[t]he greater liability in diffuse light is, no doubt, largely due to the increased accommodative efforts used in an attempt to pick out detail from the dull whitish grey surroundings, devoid of colour or shadow. . . . "[8]

Some of the symptoms will have reflected the condition now known as empty field myopia (space myopia, sky myopia) in which the eyes of people (typically pilots) looking into the distance for a prolonged period with nothing to focus on accommodate and focus on the near point.[9] This would occur not just in bad weather but when sledding on the featureless Antarctic plateau. Although this was not described in the medical literature until many years later, it was well described by Wright (a physicist traveling with Scott): "In trying to pick up depots, we often found ourselves looking up into the sky at any angle up to 30°. In such conditions also, I personally found my eyes were not focussed for infinity. Depots, when they became visible (by focussing correctly) positively hit the eye. On other occasions, I have taken the party between two 10 ft. high snow cairns a few feet apart without the remainder of the party seeing them at all."[10(p193)] The diplopia is more difficult to explain, but may have been caused by the unmasking of a latent squint in the absence of a point of fixation.

The corneal ulceration described by Atkinson[7] may reflect photokeratitis, but there are other possibilities. One possible cause is cold injury to the cornea, which has been rarely described.[11] Captain Scott found that traditional snow goggles became frosted over, and he preferred goggles made of leather or wood with a slit cut in them. Although this would restrict the ultraviolet light falling onto the eye, it would presumably leave the cornea more exposed to cold than well-fitting goggles. Another likely contributory cause is that they used large amounts of topical cocaine to treat snow blindness. Cocaine itself may cause corneal epithelial erosions,[12] and corneal anesthesia leads to decreased reflex blinking and consequently increased susceptibility to drying, foreign bodies, trauma (including trauma from wind-driven ice particles), and infection, which may be severe.[13] The mydriasis from cocaine use would itself have contributed to visual problems, and this is probably what was described by Charles Laseron, a member of Mawson's Australian expedition (1911–1914). He said that it had "the curious after-effect of distorting the lens of the eye so that it is out of focus. It made me long-sighted and for a few days everything nearer than a few feet was quite blurred. This gradually wore off, however."[14]

Atkinson described retinal changes. Retinal injury as a result of sunlight (solar retinopathy, solar retinitis) has usually been described as a result of looking directly at the sun (especially during an eclipse), but can occur in other circumstances.[15] The explorers frequently had to take off their goggles because they iced up or to improve their vision when negotiating crevassed areas: sledding on the Antarctic plateau, without goggles, could certainly provide the conditions for this to occur.

Scurvy occurred on a number of the expeditions, and although there are ocular complications of scurvy including periorbital, subconjunctival, anterior chamber, and retinal hemorrhages, these are rare,[16] and there is no evidence that these occurred on any expedition. It is interesting to compare the symptoms of scurvy as now known as a result of experiments with vitamin C-deficient diets with those given in Osler's textbook of 1907 (perhaps the standard textbook of medicine of the era). In addition to the gum disease and hemorrhages that are caused by vitamin C deficiency, Osler also described edema, feebleness and irregularity of the heart, depression, and occasional ocular symptoms such as night blindness or day blindness.[17] It is clear that the 1907 definition of scurvy encompasses much more than what is now known as scurvy and includes features now known to be caused by thiamine and vitamin A deficiency. Thiamine deficiency undoubtedly occurred on Antarctic expeditions,[18] and one author states (without evidence) that the members of Shackleton's Ross Sea party (1914–1917) were deficient in vitamin A.[19(p318)] If this was so, it might contribute to eye disease, but because their diet was a high-fat and largely meat-based diet, deficiency seems unlikely.

Figure. Burroughs Wellcome no. 91 'Tabloid' brand ophthalmic case. (Advertisement in *The Medical Press and Circular* 22 Dec 1909: x.)

Prevention of Snow Blindness

Snow goggles came in different colors: Edward Evans said that "[y]ellow and orange glasses were popular, but some preferred green,"[20(p221)] although blue and purple glasses were also available.[21] Atkinson recommended red and dark amber glasses,[4] but said that as there was much variation between glasses even of the same color, all should be tested with a spectroscope before use.[7]

As noted above, Scott preferred goggles made of leather or wood with a slit cut in them as this avoided goggles becoming frosted over.[22(p339)] This type of protection could be improvised: when the Swedish expedition was shipwrecked, "small frames of wood or wire were made and covered with the thin blue cloth from a Swedish flag."[23]

The Royal Geographical Society's "Hints for Travellers" said that "blackening the skin around the eyes, and the adjacent part of the nose, is a good deal employed by natives of high mountain regions in some parts of the world as a preventive treatment of snow blindness."[24] This was used by the *Terra Nova* northern party when they forgot their goggles.[25] The horses on the expedition also suffered from snow blindness, and on the same principle, Oates suggested that "[i]t might be a good thing to dye the forelock to prevent snowblindness."[26(p247)] They were also fitted with tassels over the eyes,[27(p355)] and mules were fitted with canvas snow goggles.[28]

Treatment of Snow Blindness

On board ship, snow blindness could be treated "by protecting the eye from strong light, and frequent bathing with warm water, boracic lotion, or, better still, very dilute zinc sulphate."[2] In the field, eye drops would freeze, and the medication was provided as small tablets designed to be put directly into the conjunctival sac.[29(p118)] Mawson, leader of the Australian Antarctic Expedition, described it thusly: "The stock cure for this . . . affection is to place first of all tiny 'tabloids' of zinc sulphate and cocaine hydrochloride under the eyelids where they quickly dissolve in the tears, alleviating the smarting, 'gritty' sensation which is usually described by the sufferer. He then bandages the eyes and escapes, if he is lucky, into the darkness of his sleeping-bag."[30(p146)]

There was another way of providing topical drugs. Taylor describes how " . . . Forde got a bad touch of snow-blindness. Debenham got out the medical chest. He ground up some ZnS04, picked it up on a paintbrush, and dropped it in the corner of Forde's eye."[31(p408)] This appears to have been a recognized treatment as the Burroughs Wellcome no. 91 "Tabloid" brand ophthalmic case (the sort taken by many expeditions; see Figure) contained tubes of ophthalmic products, a pestle and mortar, and two camel-hair brushes.[31(p84)] An alternative way of handling the tablets was the use of a "vulcanite rod which is rendered electric by friction and used for picking up the little ophthalmic discs."[32]

Scott did not think highly of this treatment, noting that zinc sulfate "is one of those remedies which might be thought to be worse than the disease, for it gives the victim what he calls 'gyp' and generally keeps him awake for the next hour or two with throbbing eyeballs," and "[c]ocaine has only a very temporary effect, and in the end seems to make matters worse."[22(p371)] Atkinson agreed that zinc sulfate and cocaine were "extremely painful and several applications were needed before they afforded any relief."[33] With increasing use, the dose of cocaine needed to be increased.[34] Laseron's comments as to how the treatment distorted vision have been described above.

Adrenaline (epinephrine) 1 in 1000 or 1 in 2000 was recommended by Atkinson as "painless and the most effective remedy,"[4,21] but Macklin warned that although "[a]drenalin[e] and pituitary extract gave striking and instantaneous relief for a short time . . . their use was

followed by an intense aching of the eye-balls and violent headache."[8]

The French expeditions used "an eye ointment containing zinc sulphate, laudanum [tincture of opium] and cocaine,"[35(p23)] and the leader of the first German expedition (1901–1903), mentions the discomfort of using "lunar caustic" (silver nitrate).[36(p242)]

Boric acid, zinc sulfate, and silver nitrate were among various chemicals used at the time for the treatment of conjunctivitis. Others included alum, carbolic acid, potassium permanganate, chinosol (oxyquinolin sulfate), corrosive sublimate (mercuric chloride), and tannic acid. These were all either astringents or antiseptics. It was thought that the benefit was attributable to the mechanical removal of organisms and inflammatory products by the fluid in which the chemical was dissolved,[37] but conjunctivitis is a self-limiting condition and the evidence of benefit from any of these agents is limited. However, many were still in use more than 40 years later,[38] zinc sulfate being used for angular (*Moraxella*) conjunctivitis[39] and silver nitrate for the prevention and treatment of neonatal gonococcal ophthalmia.[40,41] Topical laudanum was still being used by some physicians for eye problems as late as the 1940s,[42] despite it being shown in 1910 that topical opiates had no analgesic properties.[43]

Evans observed "the best cure in the world . . . to be a poultice made of hot tea leaves,"[44] and Atkinson also describes the use of this, even when other treatments were available.[21] Bage (on the Australian expedition) used "a snow 'poultice' [that] Webb had invented."[30(p303)] He does not say how this was invented, but they had probably observed the dogs as Shackleton wrote that the dogs "suffered a good deal from snow-blindness, and then they used to dig a hole in the snow and bury their faces right in; this method of treatment seemed to ease their eyes and they recovered from the attacks very quickly."[45(p425)] Charcot found cold compresses better than some conventional treatment: "I made up a lotion for our eyes, but cold compresses gave us greatest relief." An advantage of this treatment was that it was "not difficult to get hold of here. . . . "[35(p191)]

Smoke Blindness

Similar symptoms also resulted from exposure to smoke. When expeditions were marooned without sufficient stores, they used seal blubber as a fuel. According to Priestley, "[t]he term 'smoke' did not seem adequate to express the oily brown fumes which rose from our blubber stoves, but Browning provided us with a sufficiently expressive word . . . 'smitch.'"[46(p269)]

When cooking was done in an enclosed environment, such as the igloo that Scott's northern party lived in for 7 months, the lack of ventilation caused respiratory and eye problems: "The smitch from the fires inflames our eyes, and the lids press so hard on the eyeballs that they cause acute pain." This was called "smitch-blindness" or "stove-blindness."[46(p269)]

Shackleton's shipwrecked *Endurance* expedition (1914–1917), living under an upturned boat on Elephant Island, had similar problems: "there being no means of escape for the pungent blubber smoke, the inmates had rather a bad time, some being affected with a form of smoke blindness similar to snow blindness, very painful and requiring medical attention."[47(p248)]

Long-Term Effects

A number of expedition members blamed long-term eye problems on polar travel. Wilfrid Bruce (on Scott's *Terra Nova* expedition) said that with snow blindness, initially one could not see in the light, but that later, for some months, one could not see in the dark.[48(p138)] Ernest Joyce returned to the UK during the First World War and was rejected by the Royal Navy, at a time when it was desperate for men, because of poor eyesight.[19(p253)] He complained that "for over 18 months I had to wear dark glasses owing to the terrible strain of leading my parties on the Barrier."[49] When Alexander Stevens returned, he "would work late in his office peering at documents by the dim illumination of a blue light bulb—necessitated, he explained, by the damage done to his eyes by snow-blindness."[19(p270)]

Objective evidence that these explorers had long-term visual problems as a result of snow blindness is lacking, but they would certainly have been at risk of problems. Ultraviolet light has been implicated in a number of ophthalmic diseases[50,51] including pterygium, cataracts, Labrador keratopathy (spheroidal degeneration of the cornea),[52,53] and age-related macular degeneration, although its role in the latter is uncertain.

On sledding expeditions topical treatments were used for prolonged periods. Andersson on the Swedish expedition (1901–1903) describes how "as a preventative measure, I . . . dropped the solution [zinc and boracic acid] into my own eyes and Grunden's every day,"[54(p428)] and Wilson reports how he "cocainised it [left eye] repeatedly on the march."[55(p228)] Repeated use of cocaine may cause corneal opacification,[56] and prolonged anesthesia of the cornea would predispose to trauma; any resultant corneal scarring might also affect vision. Prolonged pupillary dilatation from the repeated use of cocaine for days, or even weeks, at a time may also have had long-term sequelae.

Conclusions

The problems of ultraviolet light exposure and, in particular, snowblindness are as relevant today in the Antarctic and in snowy mountainous regions[57] as they were 100 years ago. The treatment of snow blindness has, however, changed considerably.

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