Telemedicine for Frostbite Lesions

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Frostbite may cause extensive tissue damage and lead to tissue necrosis and amputation of the affected digits or limbs (1). Proper diagnosis and treatment of frostbite lesions is of utmost importance to avoid amputations and tissue loss (2). This requires experience and knowledge regarding diagnosis and optimal treatment of frostbite lesions (2).

First and 2nd-degree frostbite lesions normally heal without tissue loss, while 3rd or 4th-degree frostbite lesions often lead to necrosis and amputations/tissue loss (1, 3). The natural course of a severe (3rd or 4th degree) frostbite injury is demarcation between viable and non-viable tissue (4). This typically occurs after 1 to 3 months, and ultimately causes auto-amputation, which means that the non-viable tissue falls off without surgical intervention. Premature surgical amputation should be avoided, as natural tissue demarcation often reveals a larger amount of viable tissue than would initially be excepted (4). Thus, delayed surgery results in lower levels of morbidity and a better functional result (3). Premature surgery can cause more harm than benefit (4). Therefore, early surgical intervention should only be performed in case of uncontrolled infection (4). However, auto-amputation may take up to several months, and surgical amputation may be considered after a certain period of time, once proper demarcation has occurred (4).

Telemedicine is widely used for diagnosis and treatment of dermatological diseases (5). Teledermatology includes several modalities like store-and-forward models as well as live video transmissions (6). Advanced cameras with built-in dermoscopes are used, as well as regular cameras and mobile telephones (7). Teledermatology has particularly been successful and cost-effective in rural areas with large geographical distances and low population density, for example in Australia, Greenland, Brazil and Afghanistan (8–10).

Teledermatology may serve as an excellent modality to ensure high quality guidance and advice for frostbite lesions from regional, national and international experts (4). In this article, we aim to review and summarize the use of teledermatology for frostbite lesions.

Methods

We searched Pubmed, the Cochrane library, and Google Scholar for 'frostbite', and/or 'non-freezing cold injuries' and 'telemedicine', 'teledermatology' or 'telehealth'. We included all article types. Reference lists of relevant review articles were searched manually. We applied no language restriction.

Results

We found 15 articles related to the use of telemedicine for frostbite lesions (2, 4, 11–23). One case report published in the British Medical Journal in 2004 reports how a British climber developed frostbite of the first toe while climbing Aconcagua, the highest mountain outside the Himalaya mountain range, reaching almost 7,000 m of elevation (11). A local surgeon advised on surgery, but the climber contacted the British Mountaineering Council and uploaded photographs of the frostbitten toe (11). A British surgeon and expert on frostbite injuries reviewed the photographs, and advised against surgery. The climber made full recovery without amputation, and needed no surgical intervention during the treatment course (11).

The same authors describe in review articles how telemedicine gives access to experts in the field of frostbite and can improve outcomes in frostbite injuries (12, 13). The articles report how teledermatology can be used by both physicians with no prior experience with frostbite, and by non-medical professionals on expeditions, supplying expert advice on the treatment of frostbite lesions, and advice on whether or not to continue the expedition. The British Mountaineering Council has a website where physicians with expert knowledge on frostbite can be contacted with cases and photographs of frostbite injuries, and give diagnostic and therapeutic advice (https://www.thebmc.co.uk/how-to-get-expert-frostbite-advice). This UK-based frostbite service often receives photographs sent by satellite phones from people on expeditions, and has provided help to people in Nepal, India, Pakistan, Argentina, Chile, Namibia, Spain, Peru, Alaska, the Arctic and the Antarctic (14). These authors also report on legal issues regarding medical advice

given to physicians and non-medical professionals in other parts of the world using telemedicine (15).

The Utah Health Care Burn Center also provides a telemedical program in frostbite management (http://healthcare.utah.edu/burncenter/frostbite.php) (12). Here, a multidisciplinary approach including surgeons, wound care specialists, physical therapists, nutritionists, pharmacists, and social workers, is used to improve outcomes for frostbite lesions.

Telemedicine plays a significant role in health care at Antarctic research stations (16–18). Reports from the Australian, Japanese and British Antarctic research stations describe how telemedicine has evolved over the last 60 years from radio sound-transmissions to advanced store-and-forward image transmissions, and live video transmissions (16–18). These reports also describe the illnesses and diseases occurring at the Antarctic research stations, including frostbite (16–18).

Articles from our own group have also reported how telemedicine and teledermatology is used in Arctic Greenland (4, 19, 20). The regional hospitals in Greenland serve as referral hospitals for local hospitals and rural health clinics, and provide a 24 h telemedical service evaluating electrocardiograms, clinical photographs, otoscopic images, dermatoscopic images, stethoscopic sound files and live video transmissions (4). These modalities help guide the treatment of frostbite lesions presenting at local hospitals and rural clinics (4, 19, 20).

New modalities for telemedicine during expeditions are under development (21–23). The primary drive for developing new devices was the catastrophic Everest expedition in 1996, in which 5 climbers lost their lives (21). These devices continuously measure vital signs and other parameters like heart rate, oxygen saturation, skin temperature, core body temperature and lactate levels in the blood. Most devices are wearable, but also pill-like devices designed to be swallowed can measure core body temperature and serum lactate levels (21, 22). These devices constantly transmit data via satellites, and allow for continuous monitoring during extreme expeditions (21, 22). Telemedical information on skin and core body temperature help diagnose frostbite and hypothermia, and increase expedition safety.

Discussion

The number of people exposed to frostbite and non-freezing cold injuries is increasing. Travel to high altitude, Arctic and Antarctic areas has become more prevalent and an increasing amount of people undertake expeditions into cold and remote areas (4) (Fig. 1). Skiing expeditions in polar areas, and climbing the highest mountain peaks in the world, has become more popular and commercially available, increasing the population at risk for frostbite injuries (4) (Figs 2–4). Travel to these remote places means that health care facilities are not easily reachable in case of illness or injury, and medical equipment carried on expeditions is limited. Satellite phones and other communication devices are paramount for expedition safety. In cases of extreme weather making medical evacuation impossible, satellite phones serve as means to telemedical diagnosis, initial stabilization and treatment.

This study shows that several teledermatological programs have been developed. These programs allow for global access to expert advice on diagnosis and treatment of frostbite lesions.

Fig. 1. Skiing expedition from coast to coast of Svalbard. Food, fuel, tents and equipment was dragged in sledges, and polar bear watch was kept throughout the night. Temperatures reached a low of –30°C during the expedition. Photo: Anne Kathrine Lorentzen.

Fig. 2. Cold exposure on a Greenland expedition. Water vapour in exhaled breath quickly freezes on the mask, hood and eye lashes, and sweat from pulling heavy sledges freezes to ice on the inner linings of outer garments. Icy winds and freezing temperatures combined increases the risk of frostbite injuries significantly. Photo: Anne Kathrine Lorentzen.

Fig. 3. Storm during a skiing expedition across the Greenland Ice Cap. Temperatures reached a low of –50°C during the 600 km long expedition, and during heavy storms skiing was impossible as the risk of hypothermia and frostbite was too high. Photo: Anne Kathrine Lorentzen.

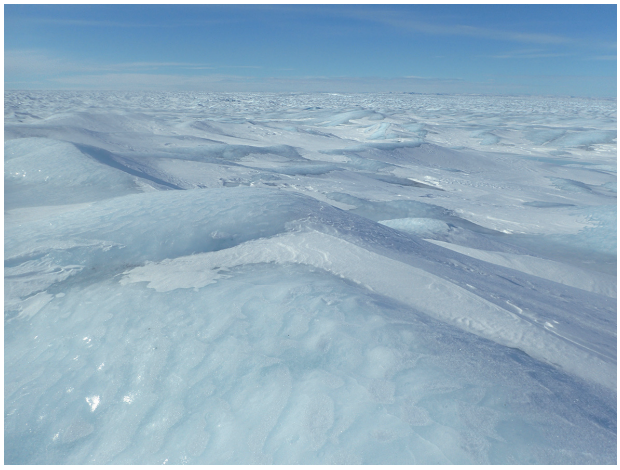

Fig. 4. The vast Greenland Ice Cap, spanning 2,600 km from north to south, and 1,050 km from east to west. Multiple organizations offer guided expeditions across the Ice Cap, and interest has grown over the past decade, putting increasingly more people at risk of frostbite injuries. Photo: Anne Kathrine Lorentzen.

Expert advice gained through telemedicine can avoid premature surgical amputation (2). Early diagnosis allows for the application of new treatment options for frostbite lesions, such as thrombolysis and vasodilating agents like Iloprost (4, 24).

Conclusion

Telemedicine is an important tool in gaining regional, national or international expert advice on diagnosis and treatment of frostbite lesions.

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