DOI 10.26724/2079-8334-2025-2-92-16-20
UDC 614.8:656.1

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THERMOCOUPLE THERMOMETRY OF THE PRE-REACTIVE PERIOD OF FROSTBITE

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With the purpose to establish features of frostbite based on express thermometry data with a thermocouple 26 servicemen with frostbite who were admitted for treatment to the thermal injury department were observed. All admitted patients underwent thermocouple thermometry using an electric thermometer. Based on our data, we proposed the following severity classification: frostbite of the I degree corresponds to +15ºC+16ºC, of the II degree to +13ºC+14ºC, of the II–III degree to +11ºC+12ºC, of the III degree to +8ºC+9ºC, of the III–IV to –3ºC–4ºC. Thus, the measurement of the surface and intra-tissue temperature in the affected area in the thermal injury department of patients with cold injuries using objective and thermocouple thermometry allows for early diagnostics and effective treatment results. As a result, the patient's intoxication symptoms are reduced, the amputation area is reduced, treatment becomes more effective, and therefore patients are discharged from the hospital earlier with fewer bed days.

Key words: thermocouple thermometry, frostbite, cold injury, military servicemen, skin temperature.

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ТЕРМОПАРНА ТЕРМОМЕТРІЯ ДОРЕАКТИВНОГО ПЕРІОДУ ВІДМОРОЖЕННЯ

З метою встановлення особливостей перебігу відмороження на основі даних експрес-термометрії за допомогою термопари було проведено обстеження 26 військовослужбовців з відмороженнями, які надійшли на лікування у відділення термічних уражень. Усім пацієнтам, які надійшли, проводили термопарну термометрію за допомогою електричного термометра. На підставі отриманих даних, нами запропоновано таку класифікацію тяжкості: відмороження I ступеня відповідає температурі +15ºC+16ºC, II ступеня +13ºC+14ºC, II–III ступеня +11ºC+12ºC, III ступеня +8ºC+9ºC, III–IV ступеня –3ºC–4ºC. Таким чином, вимірювання поверхневої і внутрішньотканинної температури в зоні ураження у відділенні термічної травми у хворих із холодовими травмами з використанням об'єктивної і термопарної термометрії дає змогу проводити ранню діагностику і отримувати ефективні результати лікування. У результаті у пацієнта зменшуються симптоми інтоксикації, скорочується зона ампутації, лікування стає ефективнішим, а отже, пацієнти виписуються зі стаціонару раніше і з меншою кількістю ліжко-днів.

Ключові слова: термопарна термометрія, відмороження, холодова травма, військовослужбовці, температура шкіри.

After the collapse of the Soviet era, 20 % of the territory of the Republic of Azerbaijan, most of which was Karabakh and the surrounding regions, was occupied by Armenian forces. For almost 30 years, the Azerbaijani people lived in a state of war for these lands that remained under occupation [11].

Military personnel serving in the territory of the Republic of Azerbaijan, which has various climatic conditions, constantly endured extreme hot and cold weather conditions. In addition, military personnel serving on the front lines, which are mainly located in high-altitude areas, attract attention. In these places, both in the cold winter months and in the usual spring and autumn months, the weather was very cold, windy, and frosty. In these places, which were poorly organized in terms of heat in the early days, soldiers were sometimes exposed to cold traumas - general colds, various types of mild, moderate, severe frostbite. Their treatment was also carried out in military hospitals, accepting military combat traumas [13].

Frostbite was one of the most difficult areas of surgery in peacetime and wartime, and was of both practical and theoretical importance. Frostbite occurs in frosty weather with temperatures below 0^0 degrees Celsius (<0^0C or <32°F), and is observed massively during wartime [1].

The cause of the pathological processes arising in frostbite is a long-term spasm of peripheral vessels, which causes changes in the vascular walls and, by irritating the sympathetic nervous system, strengthens the adrenaline syndrome and forms thrombi. The subsequent pathological processes are tissue necrosis (decay), i.e., inflammatory changes and metabolic disorders, the development of intoxication, complications with the purulent-septic stage [4, 12].

The purpose of the study was to establish the features of frostbite based on express thermometry data with a thermocouple.

Materials and methods. The study included 26 servicemen with frostbite who were admitted for treatment to the thermal injury department of the Main Clinical Hospital of the Armed Forces of the Republic of Azerbaijan (Baku) in the period of 2020–2022.

Frostbite was diagnosed based on local objective signs, in accordance with the signs of the corresponding specified degrees. In contrast to diagnostic electrothermometry, rheovasography, recording of infrared radiation with a teplovisor, angiography, ultrasound examination of peripheral vessels, thermotopographic, radioisotope, etc. thermometries carried out in previous years, in our study all admitted patients underwent thermocouple thermometry using an electric thermometer (Fig. 1).

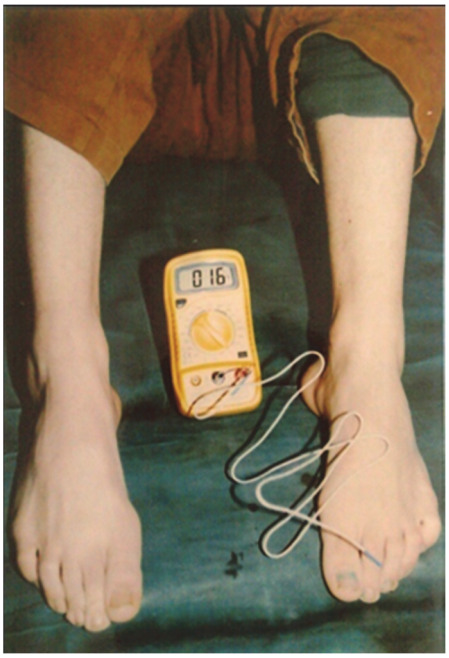

Fig. 1. External appearance of a thermocouple.

Measuring skin temperature with a thermocouple is a relatively simple procedure that uses the Seebeck principle. A thermocouple, consisting of two dissimilar conductors, produces a voltage proportional to the temperature difference between its junctions. To measure skin temperature, one junction of the thermocouple is placed on the skin and the other at a reference point, such as room temperature. The resulting voltage is then converted into a temperature value.

The position of the thermocouple strongly affects the reading of the temperature evolution thus, it is necessary to place them in the right position, in such a way that correct information about temperature is obtained. Before taking a measurement, the thermocouple must be connected to a measuring device. For example, a digital voltmeter or a thermocouple with an integrated processor, which converts voltage into a temperature value, can be used. There are several methods for placing a thermocouple on the skin: adhesive – special adhesives or adhesive tape can be used to ensure reliable contact between the thermocouple and the skin; pressing – the thermocouple can simply be pressed against the skin using a special device that will ensure stable contact; immersion – in some cases, the thermocouple can be immersed in water, in which the hand or limb is then immersed for measurement. The measuring device to which the thermocouple is connected outputs a temperature value corresponding to the received voltage. Since one junction of the thermocouple is on the skin and the other is at the reference point, it is necessary to take into account the change in temperature of the reference junction. Additional temperature sensors or compensation systems can be used for this. With this method, it was possible to measure the skin and intra-tissue temperature in any areas, make an early initial diagnosis, and create the basis for organizing treatment at the last moment [6].

In our study, the surface temperature was measured by touching the needle at the end of the thermocouple to the skin surface around the nails on the phalanges, and the intra-tissue temperature was measured by inserting the needle to a depth of 4–5 mm into the skin.

The statistical analysis was performed using Excel tables, and the following indices were calculated: mean (M), standard error (m) and Student's t-test. Results were considered significant when $p<0.05$.

Results of the study and their discussion. The results obtained demonstrated that in severe frostbite, the skin surface temperature was always higher than the intra-tissue temperature.

The thermocouple indicators of pre-reactive period when the patient was admitted with frostbite are listed in Table 1.

Table 1

Thermocouple thermometry of the pre-reactive period in patients with frostbite of both lower and upper extremities

Measurement area	Lower extremities			
	Right leg		Left leg	
	Surface t^0	Deep t^0	Surface t^0	Deep t^0
1st finger's main phalanx	-4^0	-13^0	-4^0	-13^0
2nd finger's main phalanx	-4^0	-13^0	-4^0	-13^0
3rd finger's main phalanx	-4^0	-13^0	-4^0	-13^0
4th finger's main phalanx	-4^0	-13^0	-4^0	-13^0
5th finger's main phalanx	-4^0	-13^0	-4^0	-13^0
The sole of the foot	-4^0	-13^0	-4^0	-13^0
Upper extremities				
Measurement area	Right hand		Left hand	
	Surface t^0	Deep t^0	Surface t^0	Deep t^0
1st finger's main phalanx	-3^0	19^0	-3^0	15^0
2nd finger's main phalanx	-2^0	17^0	-2^0	13^0
3rd finger's main phalanx	-2^0	13^0	-2^0	11^0
4th finger's main phalanx	-2^0	11^0	-3^0	11^0
5th finger's main phalanx	-1^0	9^0	-2^0	9^0
Palm of the hand	-3^0	13^0	-1^0	13^0
Lower 1/3 of the forearm	13^0	19^0	13^0	23^0

The temperature inside the deep tissue is much lower than the surface skin temperature. This dependence is due to the negative temperature of the skin surface when the patient entered the hospital. A hot water bath was made for 1 hour and 20 minutes on the patient's extremities. After the hot water bath was made, the extremities were wiped dry with a towel, and then thermocouple thermometry was performed on the patient's palm surface from the main phalanges of the fingers, and then from the skin surface and deep tissue ($p<0.05$). The results are shown in Table 2.

Table 2

Thermocouple thermometry performed after the patient has warmed up

Measurement area	Lower extremities*			
	Right leg		Left leg	
	Surface t^0	Deep t^0	Surface t^0	Deep t^0
1st finger's main phalanx	25^0	4^0	24^0	5^0
2nd finger's main phalanx	26^0	5^0	25^0	5^0
3rd finger's main phalanx	25^0	6^0	25^0	6^0
4th finger's main phalanx	25^0	6^0	25^0	6^0
5th finger's main phalanx	25^0	6^0	25^0	6^0
The sole of the foot	26^0	7^0	26^0	3^0
Upper extremities**				
Measurement area	Right hand		Left hand	
	Surface t^0	Deep t^0	Surface t^0	Deep t^0
1st finger's main phalanx	25^0	25^0	26^0	24^0
2nd finger's main phalanx	25^0	25^0	26^0	25^0
3rd finger's main phalanx	25^0	24^0	26^0	24^0
4th finger's main phalanx	25^0	25^0	25^0	25^0
5th finger's main phalanx	25^0	26^0	25^0	26^0
Palm of the hand	27^0	28^0	28^0	27^0
Lower 1/3 of the forearm	32^0	35^0	33^0	36^0

Note: *Room temperature $+21^0$C, ** Room temperature $+22^0$C

Based on our data, we proposed the following severity classification: frostbite of the I degree corresponds to +15ºC+16ºC, of the II degree to +13ºC+14ºC, of the II–III degree to +11ºC+12ºC, of the III degree to +8ºC+9ºC, of the III–IV to –3ºC–4ºC.

The following idea of classifying frostbite based on the restoration of blood circulation was proposed:

– pre-reactive period with tissue icing. The temperature in the tissues is less than 2–7 ° C.

– pre-reactive period without tissue icing. The temperature in the tissues is less than 8–14°C.

– period of restoration of blood circulation.

– early reactive period.

– late reactive period.

Human tolerance to cold environments is extremely limited and responses between individuals is highly variable. Such physiological and morphological predispositions place them at high risk of developing cold weather injuries (CWI), including hypothermia and/or non-freezing and freezing cold injuries. The present manuscript highlights current knowledge on the vulnerability and variability of human cold responses and associated risks of developing CWI. The cause of pathological processes that occur with frostbite is a prolonged spasm of peripheral vessels, which causes changes in the vessel walls and, irritating the sympathetic nervous system, increases the adrenal syndrome and forms blood clots. Subsequent pathological processes include tissue necrosis (decay), i.e. inflammatory changes and metabolic disorders, the development of intoxication and complications with a purulent-septic stage [3].

Prolonged exposure to low temperatures on body tissues and factors that create accompanying conditions play an important role in the development of frostbite. Thus, in cold weather, increased human fatigue, alcohol intoxication, physical inactivity, adynamia, and fainting can play a role. Local factors include vascular diseases of the extremities (obliterating diseases, varicose veins, previous frostbite of the hands and feet), limb injuries (fractures, dislocations), and wearing tight shoes. Deep frostbite can result in necrosis and may need amputation of affected tissue. Though a serious injury, it is not very well understood, and further scientific exploration is needed. This work explores the current understanding of the pathophysiology of frostbite [2, 5].

In several studies two periods of frostbite were reported: 1–pre-reactive period; 2–reactive period. The hypothermia stage refers to the pre-reactive, "latent period". This is a period of time that lasts from

several hours to a day and is the time when the internal temperature in the extremities is restored. The reactive period is the period when tissues begin to function [7, 14].

Despite of fact that data on the overall incidence of frostbite are limited, a retrospective study of 241 patients conducted by Schellenberg M, et al (2020), reported a 3 % mortality rate. In the same study, however, surgical intervention with debridement and/or amputation was required in 20 % of patients [10].

Complications from frostbite injury include local tissue swelling, tissue necrosis, gangrene, compartment syndrome, joint immobility, and contractures, amongst other physical deformities [8, 9].

According to the results of our scientific research, frostbite is considered the most severe form of cold injury, accompanied by icing of tissues. With hypothermia, blood circulation in the tissues in the area of cold damage decreases to a complete stop. In such conditions, the tissues do not necrotize due to cold impact, but go into a state of parabiosis, in which they retain the ability to maintain life for a certain period of time. All irreversible symptoms begin when the pre-reactive period transitions to the reactive one, that is, after the tissues warm up. When tissues are warmed up, metabolism is restored, and the process of burning and restoring metabolism in tissues requires normal and even greater nutrition for its viability. If tissues receive such nutrition, they are capable of normal viability and necrosis does not occur. When tissues do not receive nutrition, they necrotize from lack of oxygen and starvation [2, 7].

Haman F, et al (2022) noted that there are individual risks for cold weather injuries. Thus, the features of the course of pathological processes in frostbite depend on the depth and timing of cryodestruction, which in turn affects the outcome and prognosis of treatment tactics at the time of manifestation of the disease [3].

So, use of thermocouple to measure the temperature in pre-reactive period will be effective for early detection of injury and prevention the irreversible outcomes.

During our observation, for the first time in the diagnosis of patients with frostbite, objective clinical signs were identified. The tissues become very fragile, prone to fracture during frostbite, and the dependence of the degree of frostbite of the hand and fingers on the depth was determined. Thus, if the numbness and wood-like hardening of the fingers of patients admitted in the pre-reactive period continue to the middle phalanges, then in the subsequent reactive period, frostbite of the second degree develops, if it continues to the beginning of the main phalanges, frostbite of the third degree develops, and if it continues to the middle of the metacarpal bones or the wrist-spinal joint, frostbite of the fourth degree develops.

In the section on thermal injuries, we measure the surface and intra-tissue temperatures of the tissues in the area of injury with objective and thermocouple thermometry, and establish an effective outcome of the treatment by making an early diagnosis [12].

Conclusion

Based on our data, we proposed the following severity classification: frostbite of the I degree corresponds to +15ºC+16ºC, of the II degree to +13ºC+14ºC, of the II–III degree to +11ºC+12ºC, of the III degree to +8ºC+9ºC, of the III–IV to –3ºC–4ºC.

Thus, the measurement of the surface and intra-tissue temperature in the affected area in the thermal injury department of patients with cold injuries using objective and thermocouple thermometry allows for early diagnostics and effective treatment results. The organization of effective results of treatment by measuring the temperature of the skin surface and intratissue area in the pre-reactive period of frostbite and after warming the extremities with a hot water bath, might predispose to better outcomes. As a result, the patient's intoxication symptoms are reduced, the amputation area is reduced, treatment becomes more effective, and therefore patients are discharged from the hospital earlier with fewer bed days.

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Стаття надійшла 11.05.2024 р.

DOI 10.26724/2079-8334-2025-2-92-20-24
UDC 616.31–008.8–022+616.12/.13–002

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QUANTITATIVE DETERMINATION OF PERIODONTOPATHOGENS IN ELDERLY PATIENTS WITH ATHEROSCLEROSIS

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Dental-plaque pathogens can translocate via the bloodstream, accumulate in atheromatous plaques of various arteries, or directly infect vascular endothelial cells, thereby taking an active part in the progression of atherosclerotic lesions. We performed a quantitative analysis of the "red-complex" periodontopathogens Porphyromonas gingivalis, Treponema denticola and Tannerella forsythia, as well as Aggregatibacter actinomycetemcomitans, Porphyromonas endodontalis, Prevotella intermedia and Fusobacterium nucleatum in gingival crevicular fluid. From every patient three to six of the targeted periodontopathogens were detected when a high-sensitivity threshold was applied. T. forsythia and F. nucleatum were identified in 100 % of samples, P. endodontalis in 77.8 %, P. gingivalis in 44.4 %, and T. denticola, A. actinomycetemcomitans and P. intermedia in 33.3 %. In all study participants, onset and/or progression of atherosclerosis may, to varying degrees, be attributable to the presence of large numbers of periodontopathogens in the oral cavity.

Key words: atherosclerosis, generalised periodontitis, older age, periodontopathogens, polymerase chain reaction.

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КІЛЬКІСНЕ ВИЗНАЧЕННЯ ПАРОДОНТОПАТОГЕНІВ У ПАЦІЄНТІВ ПОХИЛОГО ВІКУ З АТЕРОСКЛЕРОЗОМ

Патогени зубного нальоту можуть транслокуватися кровотоком і накопичуватися в атероматозних бляшках різних артерій або безпосередньо інфікувати ендотеліальні клітини судин, беручи, таким чином, безпосередню участь у прогресуванні атеросклеротичних уражень. Нами проведено кількісний аналіз пародонтопатогенів «червоного комплексу» Porphyromonas gingivalis, Treponema denticola та Tannerella forsythia, а також Aggregatibacter actinomycetemcomitans, Porphyromonas endodontalis, Prevotella intermedia та Fusobacterium nucleatum у рідині ясенної часу. У зразках усіх пацієнтів виявлено від 3 до 6 аналізованих пародонтопатогенів під час використання порога високої чутливості. T. forsythia та F. nucleatum виявлені у 100 % зразків, P. endodontalis – у 77,8 %, P. gingivalis – у 44,4 %, T. denticola, A. actinomycetemcomitans та P. intermedia – у 33,3 %. У всіх пацієнтів даного дослідження виникнення та/або прогресування атеросклерозу можуть у тій чи іншій мірі бути обумовлені присутністю великих кількостей пародонтопатогенів у ротовій порожнині.

Ключові слова: атеросклероз, генералізований пародонтит, похилий вік, пародонтопатогени, полімеразно-ланцюгова реакція.

The work is a fragment of the research project "Improving the provision of dental care to the elderly under martial law", state registration No. 0123U103245.

Cardiovascular diseases (CVD) are among the leading causes of mortality in developed countries, accounting for 17.3 million deaths worldwide each year, with an expected rise to 23.6 million by 2030 owing to lifestyle changes and population ageing [15].