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GENERAL

THE ROLE OF HYDROGEL DRESSINGS IN PROPHYLACTIC SETS USED BY SOLDIERS INVOLVED IN POLISH MILITARY CONTINGENTS

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Abstract: This paper describes the available production technology of hydrogel dressings. Their practical application were tested - solid and semi-liquid - in the daily practice of medical emergency. An analysis was made of risk associated with the application of these type of dressings, and of the ability to apply them in individual prophylactic sets. The aim of the study was to compare commercially available hydrogel dressings – to the conditions and the risk of their use. Anti-burn dressings were used of three different companies, provided for the research in original packaging. The study was conducted in the laboratory. The samples of dressings were placed on a thermally insulating surface, and then for a period of 60 h with a thermocouple the temperature was measured under the dressing. The measured values were compared with measurements effected parallel to the ambient temperature. The implementation of the dressing on the surface resulted in the immediate cooling of the surface (about 10 min). Time after application of the dressing to achieve its full cooling capacity is approximately 60 min for each of the tested dressings. The maximum reduction in temperature of cooled surface was analogous for the three tested dressings and was 4.20°C. Maximum cooling times of dressings differed significantly. In conclusion**,** the dressings in the form of solid hydrogels are characterized by an easier application, they are safe during oxygen therapy and they provide a longer cooling time.

Keywords: burns, hydrogel dressings, BurnTec, Kikgel, anti-burn dressings.

First aid to a victim of burns comes to cooling the site of injury as soon as possible (1). Originally, according to the guidelines of medical emergency, it was recommended to cool burns with cold water. For less extensive burns (up to 10% of total body surface area), this solution proved to be effective, however, for a more extensive injuries cooling by running water carried a significant risk of inducing hypothermia. Currently, in emergency care almost entirely the method of cooling the burn with water is abandoned in favor of hydrogels dressings forms. Dressings of this kind are characterized by a more effective cooling, they protect the injury site from external contamination and they are sterile. The cooling process takes place not only by evaporation, as is in the case of water, but also by heat transfer from the injury to the wound dressing (heat capacity), and then transfer of the heat to the external environment. What is also very important, hydrogel dressings do not involve risk of developing hypothermia, even in very extensive burns (1, 2).

Discussing the application of hydrogel dressings in emergency care an analysis should be made on the use of Individual Prophylactic Sets, which were introduced in 2006 to equip soldiers of Polish army (3, 4).

These risks associated with the use of hydrogel dressings can be virtually eliminated by using hydrogel dressings in a solid form - now among the available dressings this feature has only the dressing of Polish production BurnTec. Due to its homogeneous structure the dressing ensures the uniform distribution of the refrigerant at the burns surface, even for the most extensive injury. Stable structure also eliminates the possibility of any spills or damage of a cooling hydrogel. Using the dressing in the form of the face mask assures that the hydrogel does not get into the respiratory tract even in the case of oxygen therapy. Clinical experience has shown that even the large patches of hydrogel adhere well to the wound bed and they are quick and easy to apply, and in case of an unconscious, mechanically ventilated patient, the supporting dressing is not required. In the case of

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semi-liquid dressings for all parts of the body, apart from the face exposure, the risk may be acceptable. When marking faces, the risk of getting the cooling substance to the body cavity is so high that it can not be accepted, but it is 100% possible to eliminate this through the use of hydrogels in solid form. It is worth noting that the BurnTec, the only one dressing used in the rescue, is also used in the treatment of patients in the clinical departments. Using hydrogel dressings the shallower burn therapy is carried out (up to level 2a) as well as they are used in the case of deeper injuries due to the supporting features of cleaning the surface of the wound from necrotic tissue (1, 5, 6).

The form in which the dressing appears may effect the absolute values of cooling. A study in the laboratory indicated significant differences in the cooling time by a particular dressing. The samples of dressings were placed on a thermally insulating surface, and then for a period of 60 h with a thermo-

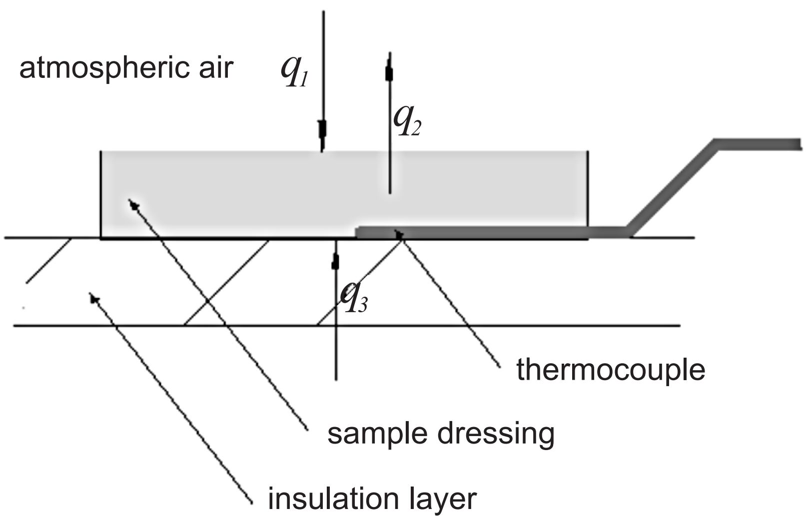

Figure 1. Measurement scheme

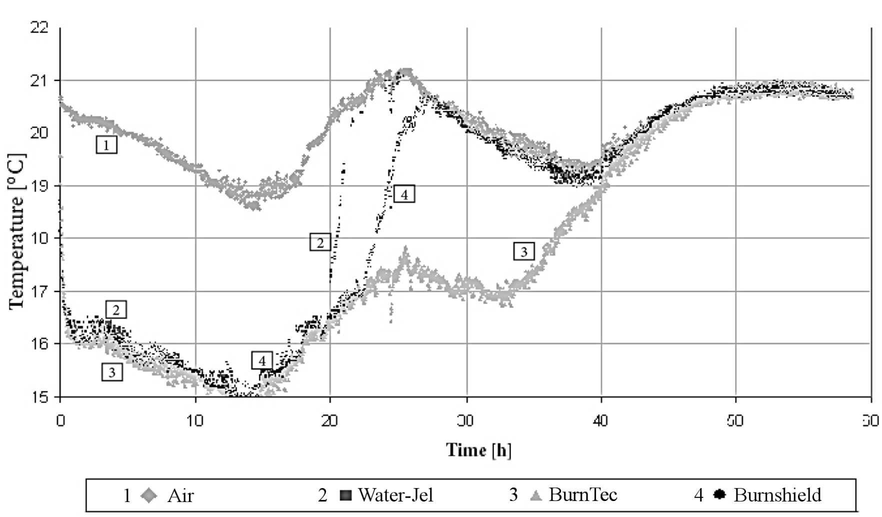

Figure 2. Dressings and ambient temperature during the experiment

Table 1. Dressings used in the experiments.

Dresssing	Company	Country of origin	Dressing type
Water-Jel ®	Water-Jel Technologies	U.S.A.	10 × 40 cm (cat. no. 0416)
Burnshield	Levtrade International Ltd.	South Africa	10 × 10 cm (burn dressing)
BurnTec	Kik-Gel[1]	Poland	10 × 10 cm (standard)

[1] BurnTec - previously known as Aqua-Gel.

couple the temperature was measured under the dressing. Next, the measured values were simultaneously confronted with the ambient temperature measurements. It allowed to investigate the actual cooling dressings properties. Figure 2 shows the differences in the ambient temperature and the temperature measured under the dressing.

The semi liquid dressings remained cooling properties for less than 30 h, only the dressing BurnTec cooled surface by more than 40 h (6, 7). This fact is particularly important in the context of the burnt patient's further treatment. BurnTec due to its compact structure protects an injury site against infection and prevents the ingress of microorganisms on the wound surface. The dressing also provides a moist healing environment that provides the acceleration of epithelialization and granulation. Often, due to these characteristics, the patient with the burns, transferred to a unit, is left in the dressing BurnTec, and as mentioned above, the treatment is continued with the use of hydrogel by regular dressing changes.

MATERIALS AND METHODS

The study was designed to compare the ability of cooling gel dressings. Anti-burn dressings of three different companies supplied by the client were used for the comparison. The dressings were supplied in their original packaging. The types of dressings used in the experiments are shown in Table 1 (7) .

These dressings are used in the treatment of severe skin burns. Their action is based mainly on protecting the wound and its cooling by evaporation of water contained in the dressing. The cooling capacities were tested under laboratory conditions by constant temperature measurement of a surface which is directly under the dressing [5-7].

Preparation of experiments

In order to obtain reproducible and comparable results, the temperature measurement were done with the use of thermocouples for thermally insulated surface on which the compared dressings were placed. The measurements were carried out under natural convection (without forced air flow). Figure 1 illustrates a diagram of measurement.

In the diagram, the arrows symbolize the direction of a heat flow during the process. The *q1* flux corresponds to the heat supplied to the dressing from the surrounding air, the *q2* flux this is the heat which departs from the dressing along with the evaporated moisture and is consumed on the transition phase of evaporating liquid , and the *q3* flux is the heat which in real terms comes to dressing from the skin of a patient, which is located under the dressing. Under the conditions of the experiments, due to the application of the insulation under the dressing, the *q3* flux is zero, and the read temperature is different from a system in which instead of the insulation under the dressing the skin of the patient is present. However, this does not affect the possibility of dressings comparative test system.

During the experiment the download of heat was associated with the evaporation of water. The evaporation resulted in lowering the temperature of the dressing. The lower temperature resulted in lowering the temperature of the dressing surface of the insulation placed under it. Thermocouple measured the temperature under the dressing. The comparison of this temperature with the temperature of the drying air allowed for the calculation of the temperature drop and at the same time the cooling capacity of the dressings.

Experiment carried out under the conditions described above, allowed the easy and reliable comparison of the cooling capacity of tested dressings.

The test apparatus

The test patches were placed on the pad of insulating material, heat insulating and preventing the flow of liquid and gas. The measurement of temperature profiles was performed using a thermocouple (type J, model TT-J-30, producer: Omega Engineering Inc., USA, 0.10°C accuracy within the range tested). Readings from the thermocouples were recorded on the computer.

Conditions of the experiment

1) Atmospheric pressure: 998 hPa. 2) Temperature: Room: 18°C to 22°C. 3) The speed of the ambient air: 0.00 to 0.25 (± 0.1) m/s. 4) The time of the experiment: the loss of cooling capacity of 99% of the wound dressing (ca. 48 h). 5) Sampling: temperature was measured every 10 s for the duration of the study. 6) Samples of dressings were of dimensions 30 × 40 mm (± 1 mm). 7) Number of experiments: 4, including three, which were used to develop results.

In each experiment, the air temperature and the temperature for each of the tested dressings were measured at the same time. In order to obtain reliable results and to estimate the repeatability of tests, four experiments were carried out, each time dressings was dried for 2 days. The dressings used for experiments prior to implementation on the experimental plot were in their original packaging.

RESULTS

Figure 2 shows the results of one of the experiments.

For these conditions, the results of the experiment were as follows: Implementation of the dress-

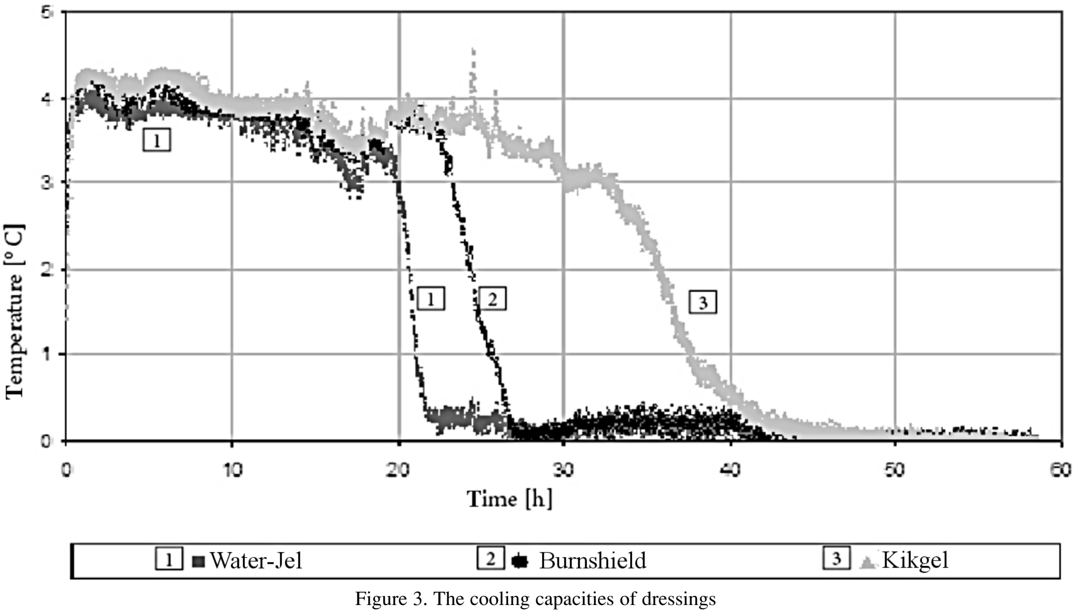

Figure 3. The cooling capacities of dressings

Table 2. Dressings used in the experiments.

Dresssing	Commencement of cooling[1] (h)	Moment of for maximum cooling capacity (h)	Maximum cooling time [2] (h)	Moment of end cooling [3] (h)
Water-Jel ®	0.01	1.00	19.60	21.80)
Burnshield	0.1	1.00	22.40	27.00
BurnTec	0.1	1.00	28.00	42.20

[1] All times in the table are measured from the beginning of the experiment. [2] The time at which the cooling temperature is about 90% or less of the maximum temperature of the cooling of the dressing. [3] The time at which the cooling temperature is ca. 10% or less of the maximum cooling temperature of the dressing.

ing to the surface causes an immediate cooling of the surface (about 10 min). Time after application of the dressing to achieve its full cooling capacity is approximately 60 min for each of the three dressings. The maximum reduction in the cooling surface temperature was similar for the three treatment dressings and amounted to 4.20^{o}C. Dressings maximum cooling times varied. The results are shown in Table 2. The results are averaged based on three experiments.

Figure 3 shows the difference between the ambient temperature and the temperature readable under the dressing. These are therefore the actual values of the temperature reduction by dressings.

For these conditions, the results of the experiment are the following: All the dressings tested were similar in the starting cooling time and maximum cooling capabilities. The dressings were different in the maximum cooling time and the total period of cooling. Water-Jel dressing had the fastest time of maximum and total cooling, while the dressing BurnTec showed the longest cooling time (both maximum and total). Burnshield ranked in the middle.

The temperature drop obtained by each of the dressings was comparable at around 4-4.20^{o}C. Due to the accuracy of the measurement (the thermocouple accuracy of 0.10^{o}C) it can be considered that the dressings received the similar temperatures during maximum cooling period.

Measurements were carried out to compare the cooling properties of dressings, but there was no real purpose of indicating the real human body temperature drop when a burn dressing was applied.

Attention should be paid to the structure of the Water-Jel® and Burnshield dressings for which due to the presence of non-evaporating substances it is difficult to obtain reproducible results. Water-Jel and Burnshield dressings exist in liquid form covering and filling the solid skeleton (the media), which evaporates during the process, and some of the liquid each time remains unused (still in box). Still, when the samples were set, the appropriate wetting of Water-Jel and Burnshield dressings was ensured with suspensions, which were stored in the package.

CONCLUSIONS

The dressings were tested in the form of flexible sheets of solid hydrogels and other semi-liquid scalding dressings. As shown, the dressings in the form of solid hydrogels are characterized by an easier application, there is no risk during the procedures of oxygen therapy, they provide a longer cooling time.

Based on the experimental series it can be concluded that the cooling capacity of dressings are compatible taking into account the maximum degree of reduction in temperature. Due to the higher weight of the evaporation per unit of surface dressing in comparison to the other products, the dressing BurnTec longer maintains maximum and the total cooling capacity. It is therefore suitable to introduce this type of antiburn dressings for prevention kits for individual soldiers and military employees leaving for the area of stabilization missions of Polish military contingents.

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