Monitoring of Temperature while Cooling Burn Injuries

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RESULTS of Preliminary Tests

The cooling of burn-victims prior to clinical treatment has established itself as an immediate course of action for burn injuries. The simple first-aid procedure can readily be done by a layman or assistant and interrupts the continuing effect of the heat and results in considerable reduction of pain.

However, the cold-water treatment of certain risk-patients can lead to excessive cooling with resultant clinical symptoms.

Some burn-specialists used this observation to refuse the cold-water treatment altogether prior to professional procedures.

It is purpose of this study to examine the relationship between established means of cooling and Hypothermia. The findings will be incorporated into concepts of monitoring and treatment of severe burns.

Cold-Water Treatment of Burns and Scalds

The Cold-Water Treatment of Burns and Scalds can greatly influence any thermal injury of the skin. One of the main effects is the interruption of further heat damage. The heat accumulating in the lower layers of the skin is being drawn to the outer layers and thus prevents any further damage due to the so-called "After-Burn". Where cooling is omitted, the effect of this after-burn can quickly change a primary second-degree burn in to a third-degree damage with loss of sensibility. (sic) Shortly after starting the application of cold water, one can – in certain patients – observe an effective reduction of pain. This curative effect results from the interruption of the damage caused by the heat, but also of blocking of the release of tissue damaging factors (mediators sic) or carriers additionally have a pivotal influence on the development of diseases resulting from burns. A massive release of these leads to an increase of leakage of the capillaries with resultant development of edema, low pressure due blood-vessel dilation and finally to an ARDS syndrome of the lungs. (6, 8, 12, 13, 14, 15)

The literature lists various recommendations for the application of cold water treatment. Mostly, a range of from 15 to 20^0 C (59 to 68^0 F) is recommended for (1, 9, 14, 15) optimal water temperature. A range of from 10 to 30 minutes is stated for the duration of cooling – or cooling till pain diminishes. Effective reduction of heat can be accomplished through flowing water, but requires quite a volume. This method is practical only where either a shower or water from a hydrant is readily available.

Where such facilities are not available in a reasonable short time, cooling of the affected skin area can be accomplished by submersion in a water bath or by the application of moist compresses. (6, 8, 12, 13) Cold Water Treatment should start as soon as possible after the exposure to heat. Should this be delayed, it is still highly recommended, since positive results can be expected even 45 to 60 minutes after the accident. (8, 12, 13)

Cold Water Treatment of Children

Relative to their body mass, children have a larger skin surface than adults. This leads to a greater and faster loss of heat while applying a cold water treatment. Infants and small children in particular show – after a short cooling duration – a clinically relevant drop in body temperature till Hypothermia may even manifest itself. (8, 9, 13) In case of an emergency situation, one must be aware of the danger of cold water treatment of a child burn victim leading to life-threatening danger due excessive cooling.

Excessive Cooling due to Cold Water Treatment

In addition to infants and small children, there is another group of patients endangered by the application of cold water therapy due to excessive cooling (Hypothermia) as per table # 1. With these high-risk patients one should apply the cold water treatment most sparingly and only under complete control of all vital signs. (2, 6, 7, 11, 13, 14, 15) Specialized intensive-treatment centers repeatedly receive patients with a body temperature as low as under 30^{0} C (86^{0} F). This situation leads many burn-specialists to categorically oppose the application on any pre-clinical cooling treatment. (14, 15)

Table # 1 Patients at risk of Hypothermia during Cold Water Treatment

Babies and Infants
Patients with burns over large areas of their body
Patients with burns at the vital parts
Older Patients
Patients in obvious shock
Patients with multiple traumas

Status of Temperature

Most Textbooks and article contain guidelines for cold water treatment to help manage the therapy of burns and scalds. For the generally accepted recommendations of running water at 15 to 20^{0} C(59 to 68^{0} F) for 15 to 20 minutes, we find no reference to any systematic studies. To understand the effect of cold water treatment on the status of the body temperature we conducted some experiments using volunteers aged 27 to 33.

To record body temperature status, parallel measurements of rectal and ear temperature (Infrared tympanum membrane thermometry) were taken. These tests were conducted under medically standardized and exacting conditions:

- Cooling of an upper extremity (Arm to shoulder)
- Cooling of a lower extremity (Leg to thigh)
- Cooling of both lower extremities (Leg to midriff)

The same volunteer was used for recording temperatures of each test, all done with 15 to $20^{\underline{0}}$ C (59 to $68^{\underline{0}}$ F) flowing water. Duration of cooling was 20 Minutes, ambient room temperature a constant $20^{\underline{0}}$ C ($68^{\underline{0}}$ F).

RESULTS

Cooling of one extremity (Arm or Leg)

While cooling one extremity only, non of the volunteers showed a relevant drop in body temperature. Both rectal and ear temperature recorded a constant behavior during the entire 20 minute cooling and the subsequent 60 minute recover period. Interesting observations were made with one small volunteer: he weighed 49 Kg (108 lbs) and his height was 153 cm (5 ft.) akin to a 14 year old.

While cooling with a slightly warmer water at $20^{\underline{0}}$ C ($68^{\underline{0}}$ F) there was a greater drop in basic body temperature then when applying the cooler $15^{\underline{0}}$ C ($59^{\underline{0}}$ F) water (Diagram 1) all as measured at the tympanum. His rectal temperature showed no change.

At the end of each cooling period – at both water temperatures – a slight albeit delayed lowering of body temperatures was noted. Using the same volunteer, these observations were repeated for both the upper as well as the lower extremities. Repeating the identical tests showed the same results. Our explanations for this observations points to a greater Vaso-Restriction in the extremities when applying cooler Water at $15^{\underline{0}}$ C ($59^{\underline{0}}$ F) than with $20^{\underline{0}}$ C ($68^{\underline{0}}$ F) water. As a result – at the lower temperature – less cold blood from the extremities takes part in the circulation than at the higher temperature, while the body temperature remains close to constant. Whether these observations have any clinical relevance for the cooling of children burn-victims or apply to a unique species only needs to be further explored by repeated observations and measurements.

Cooling of both extremities

While cooling both extremities to midriff, we were observing relevant lowering of temperatures with all volunteers. (Diagram 2) One was able to demonstrate, that the recommended cold water treatment for a period of 20 to 30 minutes, even when applied to healthy volunteers, can trigger Hypothermia.

Monitoring the rectal temperature showed a long delay of the influence of cooling. This temperature recorded a drop only 50 minutes after start of the cold water treatment.

While measuring the body-temperature in the ear (Tympanum Thermometry) a drop was discernable already while applying any cold water treatment.

Use of Temperature Measurements in Emergency Medicine

In emergency medicine, the most widely used method of temperature measurement – to date – is rectal temperature reading, viewed for the longest time as the "gold standard".

However in addition to the above described "Delay-Effects" due to slowed recognition of temperature changes, there are possibly other factors putting the accuracy of this method in question. Thus the incidence of local infection or the heat-producing activity of naturally present digestive bacteria result in false high readings and may make it difficult to assess the exact body temperature. Hypothermia requiring therapy should thus be considered, even where clinical symptoms are absent. The position of the thermometer in the rectum plays an important roll as well. Depending on the location of the thermometer tip, temperature differences of up to 0.9^0 C (1.6^0 F) can result. The usefulness of repeat measurements thus depends on the precise location of the rectal thermometer in the large intestine. The pre-clinical readings of rectal temperatures do not permit conclusions as to the relevant body temperature of the patient. It is thus not a suitable criterion for monitoring the temperature of emergency patients.

Meanwhile a new temperature measuring method – Tympanum Thermometry – is now available. This new approach evaluates the infrared heat radiation of the Tympanum using a special ear sensor The Tympanum is extremely well suited for the exact measurements of basic body temperature, since it and the body temperature control center in the Hypothalamus are both supplied with blood and thus with "heat" by the Carotid artery.

With proper use of Tympanum Thermometry we can obtain very exact values of therapeutically relevant central body temperatures. Temperature changes are noticed faster than with rectal measurements. Altogether, the Tympanum Thermometry method, due to its simple application and exact reading of basic body temperature is especially well suited for monitoring the pre-clinical patient.

SUMMARY

Using the generally recommended cold-water treatment for 20 – 30 minutes over large body areas can trigger clinically relevant Hypothermia even with healthy test volunteers. We can assume that such prolonged cold water treatment within high-risk groups would result in more severe consequences of Hypothermia. With babies and small children one can expect Hypothermia after much short cooling applications. While monitoring the body temperature during and after cold water applications it was proven that rectal temperature measurements are unsuitable due long delays in indicating the status of body heat. Using the Tympanum Thermometer one can observe a drop in temperature already during the cooling period.

PRACTICAL GUIDELINES

Pre-clinical cooling has proven itself as an immediate burn treatment, and in our opinion should be continued. To avoid or reduce the effects of Hypothermia, thorough and repeated body temperature measurement during and after the cooling phase must be taken, using the ear thermometer. At the first sign of a continuous temperature drop, cold water applications must be stopped. Only after stabilization of basic body temperature may the cooling treatment be continued.

RECOMMENDATIONS FOR MANAGING PRE-CLINICAL BODY COOLING

In addition to the classical cooling with cold water, applications of special burn-treatment remedies are used in emergency medicine. These commercial remedies include mostly sterile wound pads in various forms. Cooling is accomplished by moistening the pads with a sterile solution of table salt. Most systems work by using the principle of "Evaporation Cooling". This principle is based on the loss of calories during evaporation of a liquid. In practice one can readily observe this effect, as one feels cold at an area where an alcohol-containing disinfectant was applied.

When using an isotonic table salt solution, the cooling effect is somewhat reduced, although sufficient to cool the skin after burns. (*An isotonic salt solution has the same osmotic pressure as blood {passing through a membrane} so as not to destroy the red blood corpuscles when getting into the blood stream.)* However while cooling the midriff or with high-risk people, these burn treatment remedies can still trigger therapy-requiring Hypothermia.

An exception is the principle used to make **Water Jel®** burn compresses effective. **Water Jel®** is a special gel, resulting from the combination of demineralized sterile water and a gel-carrier. The consistency is about the same as the well-known "Defi-Gel". In addition, **Water Jel®** includes a natural oil with properties to block the growth of bacteria. (Tea Tree Oil) With this addition, the danger of infection of burn wounds is reduced, and a already infected wound will be disinfected. (4, 5, 16)

When covering a burn with a **Water Jel®** pad, cooling is accomplished by drawing the heat away from the body surface into the gel. As a result, the subcutaneous temperature at the burn area will be immediately and substantially brought down, accomplishing a rapid reduction of pain sensation as well as a reduction of shin tissue destruction. (4, 10, 16)

Evaporation with its accompanying heavy heat loss is very limited. Severe heat loss, which can happen with large area burns and distant transportation of the victim is prevented when cooling with **Water Jel®** compresses. (10)

TESTING

To analyze the trend of temperature changes while cooling a burn wound with **Water Jel®** compresses and to obtain comparable control data, we used identical test conditions while cooling with flowing water as well. (See also above) We covered the volunteers with a **Water Jel®** blanket – both legs up to and including the hips. Temperature measurements were taken in the rectum, at the tympanum and on the skin surface.

RESULTS

The skin temperature was effectively reduced when applying the gel burn blanket.

There was no apparent clinical lowering of body temperature during the cooling phase. (Diagram 3)

In a direct comparison with cold water treatment, it was shown that when cooling with the **Water Jel®** rescue blanket, no Hypothermia could be induced. (Diagram 4)

We conclude that the application of gel compresses in the treatment of burn wounds offers substantial advantages when compared to cooling with cold water.

In addition to a substantial reduction of pain, and the cooling and bacteriostatic effects (*preventing the growth of bacteria*) of **Water Jel®**, it is the portability and universal availability of this cooling method, which offers a significant improvement in the quality of pre-clinical treatment of severe burn victims.

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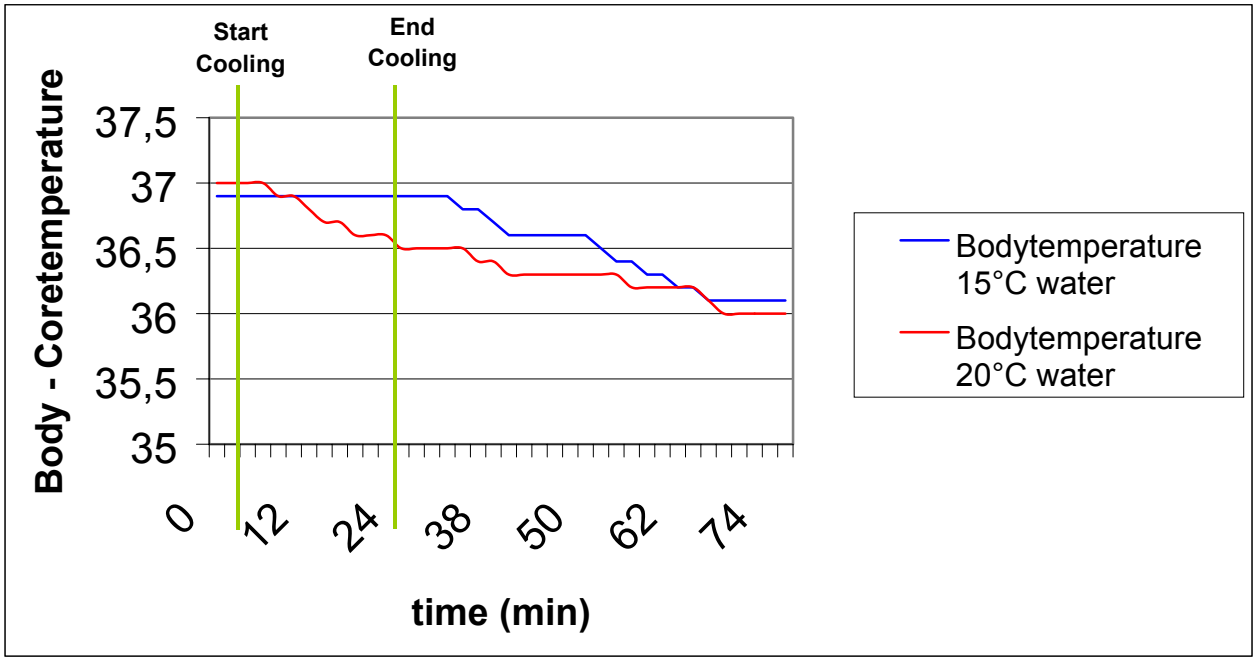

Diagram 1: Comparing Temperature Readings while cooling one leg with 15 C (59 F) and with 20 C (69 F) cold water, using a small volunteer.

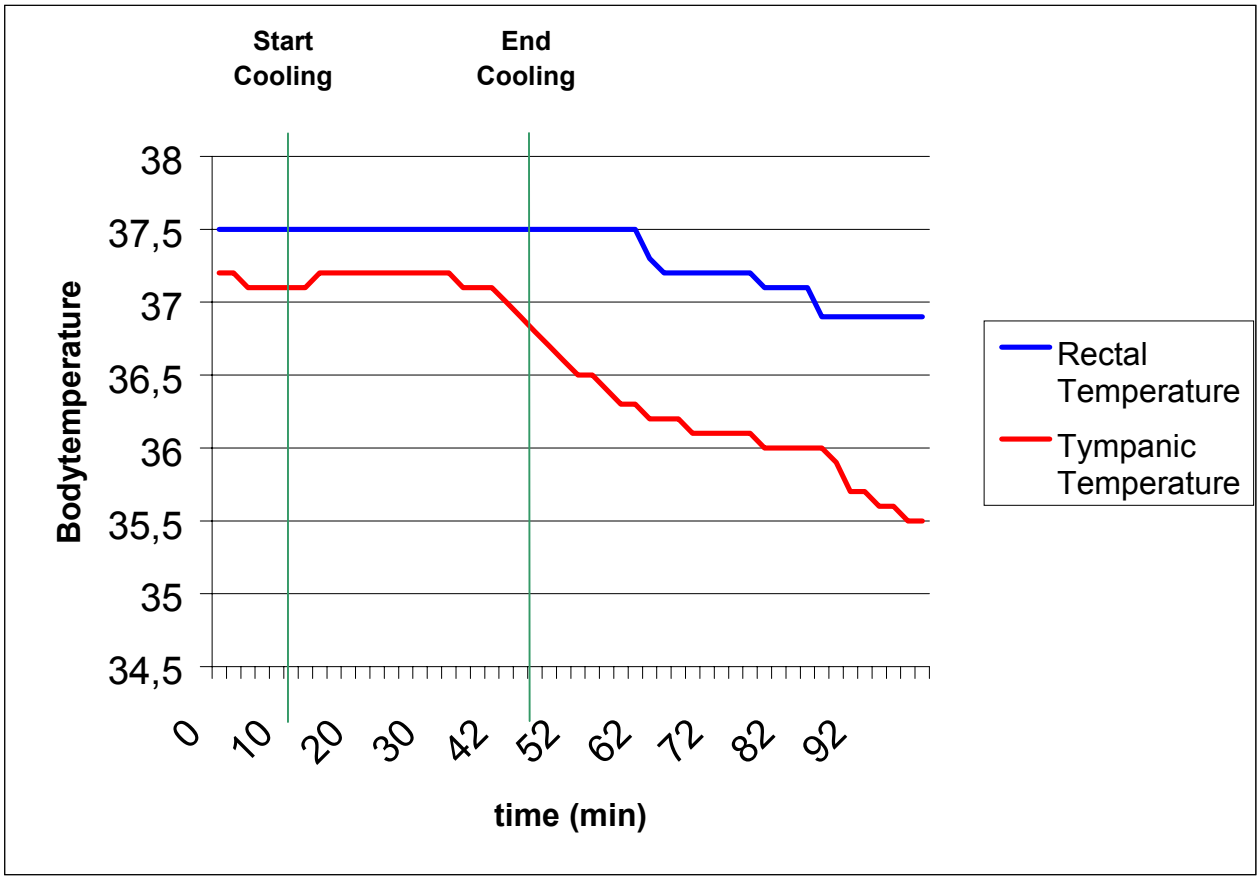

Diagram 2: Comparing Rectal Body Temperature with Ear Temperature while cooling both legs with 15 C (59 F) cold water.

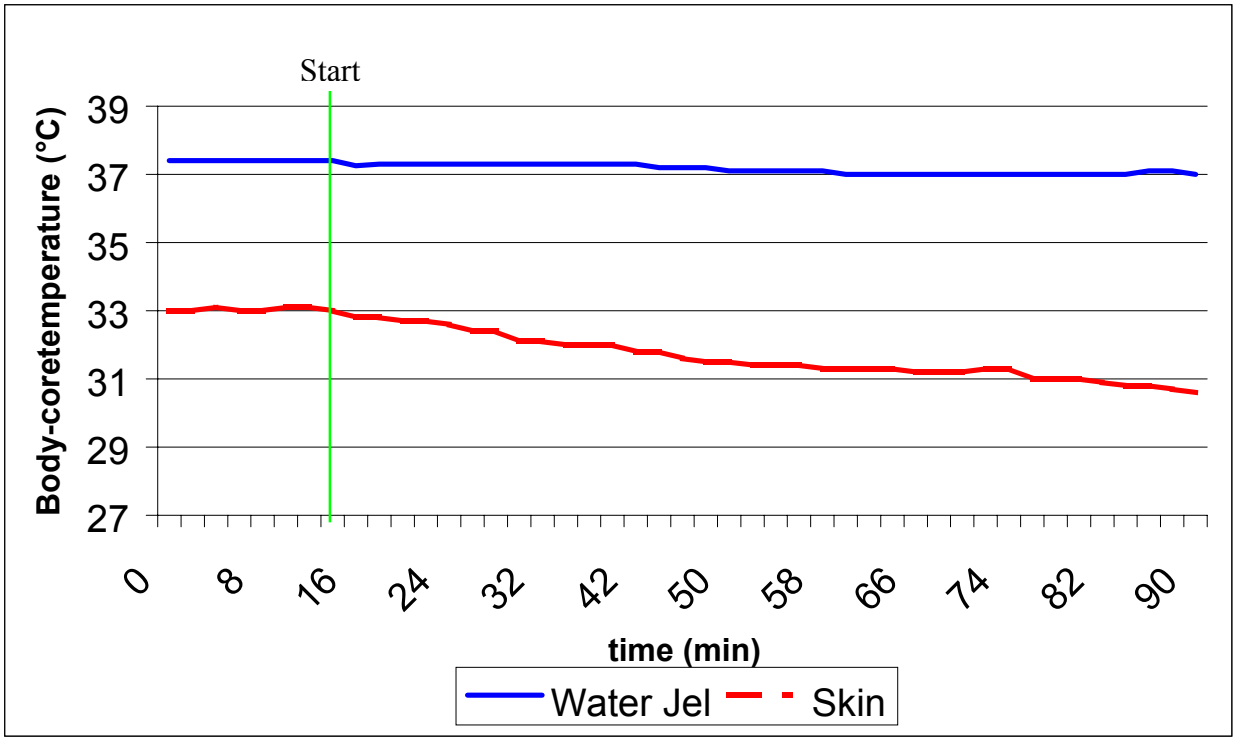

Diagram 3: Comparing Body Temperature with Skin Temperature while cooling bith legs with a Water Jel Blanket

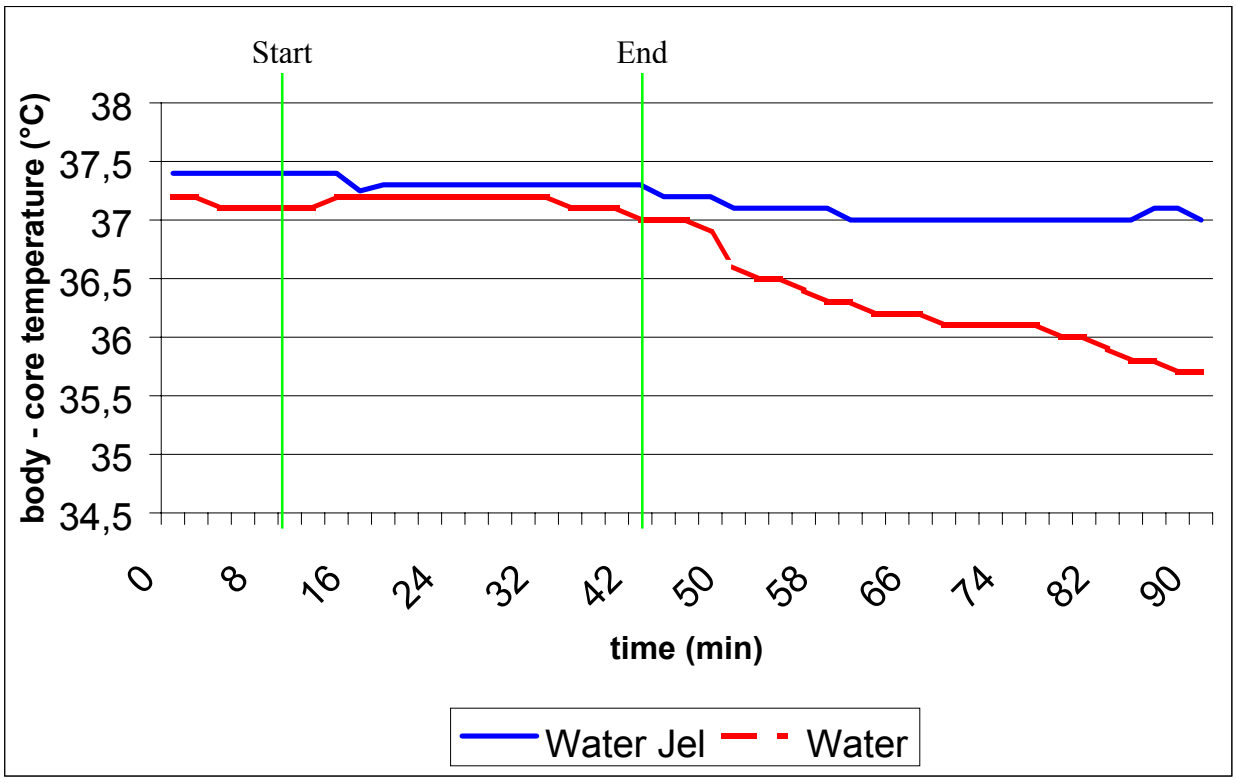

Diagram 3: Comparing cooling of both legs with 15 C (59 F) cold water and with a Water Jel Burn Blanket