COLD AND THE DIVER
Physiology and First Aid of Hypothermia

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In deep commercial diving, with long in-water times, and especially if breathing helium/oxygen mixtures, cold exposure is a major problem that has been extensively studied. Hot water suits and insulated helmets are the dress now most often used off shore to prevent heat loss to the water. For deeper dives however the heat loss from the lungs to cold, dense breathing gas can be so large that gas heating becomes necessary If not adequate pulmonary problems can arise and hypothermia can occur despite maximum hot water suit heating.

This article however is aimed more at those involved with recreational scuba activities and other forms of air-breathing diving. In these situations, the increased risks of diving that results from cold exposure are most important. All who venture onto or under our Southern Australian waters are aware that cold can be an important factor in their activity. The scope of the increased risks that cold exposure can cause the average diver is not, however, widely appreciated. Hypothermia is only one of these risks of cold stress, however should it occur appropriate first aid and medical treatment are important. Regrettbly, many misconceptions continue to0 be taught and it is hoped that the following may help to dispel some of these.

Physiology

Man is a homeotherm, with a core temperature that is usually held within an approximately 0.5 degree range close to 37°C. Short term reversible variations of up to 2°C both up and down can however occur in healthy people. It is not uncommon for elite marathon runners to finish a race with a core temperature near 39°C and this level is probably approached by many when vigorously exercising in the heat or after a prolonged sauna or hot tub exposure. Likewise, significant cold stress can in some circumstances, such as when surfing or diving, reduce the core temperature significantly. A characteristic of such changes in core temperature is that the victim takes a prolonged time, up to several hours, before feeling fully recovered (and perhaps ready for a repeat exposure) even when there is no significant exhaustion involved.

Whilst immersion in water, which has a heat conduction of twenty-three times that in air and heat capacity per litre over 3,000 times that of air, is the main source of heat loss for divers, evaporative loss when out of the water should not be forgotten. Warming one litre of 10°C sea water to a comfortable 30°C requires only 80 kiloJoules. Evaporating the same water however requires some 2,500 kJoule, much of which may be extracted from the body under the soaked clothing or wet suit! Although neoprene provides good insulation, the outer surface of most wet suits is perfect for enhancing evaporative cooling and a windproof jacket should therefore be a requisite for divers from small boats in adverse weather when there will be no opportunity to dry off for some time after the dive, except by chilling evaporation.

Whatever the mechanism of heat loss, should its magnitude exceed heat production by the body cold stress results, with the core temperature beginning to drop once the body's defence mechanisms of vaso-constriction, peripheral cooling and increased muscle activity (including shivering) prove inadequate.

Hypothermia is usually defined as occurring when the core temperature has dropped below 35°C. It is cold exposure and cold stress not sufficient to reach this level however that causes the most common effects of cold on the diver.

Cold and the Diver

Cold exposure causes constriction of peripheral blood vessels and therefore reduction in skin and muscle blood flow. This causes expansion of the central blood volume which activates the familiar cold diuresis. Upon rewarming, the subject as a result is significantly dehydrated, a factor believed to both increase the risk of decompression sickness (DCS) and increase its severity should it occur.

When commercial divers first began using hot water suits, especially for surface decompression diving, a large increase in DCS incidence was seen. It was proposed that this was due to excess heating whilst on the bottom, resulting in vasodilatation and increased blood circulation and nitrogen uptake, with subsequent cold exposure during decompression, especially in a cold chamber, retarding off-gassing. Certainly reduced hot water temperature and heated chambers seem to have solved the problem. The same mechanism however may be present for wet suit divers who are initially warm enough for the first part of a dive, but chill progressively and are especially cold during the first half hour after the dive when wind exposed and still wet.

It is unfortunately not well recognised that perception of thermal comfort does not always correlate well with actual thermal status. Because skin temperature receptors are more sensitive to change in temperature than absolute temperature, and do not measure heat flux, it is possible to have a dropping core temperature without shivering, or an excessive sensation of cold. This can most readily occur when a slight increase in surface temperature gives a feeling of warmth and inhibits shivering whilst heat loss proceeds. The most familiar illustrations of this for many will be cold tap water feeling warm to the hands initially after they have been severely chilled, or cold seawater feeling warm after wet skin has been chilled by evaporation in the wind. This mechanism has probably been one factor responsible for a number of deaths of rescued hypothermia victims who were wrapped in warm dry blankets that gave an initial sensation of comfort which stopped shivering without providing the thermal capacity or insulation needed to prevent continued rapid net heat loss in the face of reduced heat production by the body. Perhaps as a result of this problem divers can lose body heat significiantly at time without necessarily being aware of being cold

It is likely that many divers finish their dives, especially in winter and spring, with significantly reduced core temperatures, and certainly with a cold periphery and reduced body heat. In addition to increasing DCS risk, such cold stress has been shown to affect judgement, including the speech and appropriateness of emergency decision making and the actual judgement of time. Irrational behaviour is more likely. Limb cooling results in reduced muscle strength, speed and co-ordination, which is further severely affected if shivering occurs. Thus cold stress not only significantly increases the risk of accident or error in procedure, but makes the diver less effective in coping with incidents such as out of air, entanglement or a dislodged regulator etc. should they occur.

Cold Water Immersion

In addition to drwoning and hypothermia sudden exposure to very cold water without adequate wet or dry suit insulation carries an additional risk of rapid immersion shock related death.

The first, relatively rare mechanism for this is probably a combination of intense sympathetic and vagal stimulation that triggers a fatal cardiac arrhythmia. The victim, often young and apparently healthy, falls, or dives, into cold water and dies instantly.

The more common situation involves the victim drowning within minutes of hitting the water. Sudden cold water immersion causes an initial involuntary gasp reflex followed by a period of uncontrollable hyperventilation. There is a period of much rigidity and unco-ordination which resolves after a few minutes until actual muscle and nerve tissue cooling causes its return.* Unless the water is calm and a lifejacket is worn, it is thus easy for drowning to occur upon immersion and this mechanism probably accounts for most of the shipwreck and "man-overboard" deaths within seconds to minutes of hitting icy water that have often been wrongly ascribed to hypothermia.

* The Deputy Editor once saw theis happen to a plump RANR diver, wearing a wet suit, who went into 4° C water, on a 35° C day, below Eildon Weir wall. His comment on being hauled to the surface by his buddy line was "I'd have died if I hadn't had my regulator in. I couldn't stop breathing and I coul not move." The other five divers bobbed to the surface quite normally.

Although cooling rates vary widely, even a lean, unfit cold susceptible individual should survive at least 15 minutes in ice water before hypothermic cardiac arrest and better insulated idividuals should last an hour or more. In fact, the effects of dropping body temperature on muscle activity and conscious state usually results in drowning long before fatal cardiac cooling occurs.

Hypothermia

Classically, cooling has been shown as occurring progressively with specific signs and symptoms appearing at various temperatures as shown in Table 1.

TABLE 1

Core temperature (ºC)	Signs and symptoms
37	"Normal" temperature (oral)
36	Shivering,
	Vasoconstriction
	Increased activity
35	Shivering maximal
	Slurred speech
	Slow
	Confused
	Dilated pupils
	Drowsy
	Low blood pressure
30	Shivering ceases
	Muscle rigidity
	Victim no longer able to self warm*
	Very slow pulse and respiration
	Unconscious
	Heart irregularities develop
25	**Death**

An example of the type of table often appearing in medical texts and first aid guides. The temperatures at which various signs and symptoms appear in fact varies widely with differing situations.

* This statement is not true (see page 35)

There have been a number of major sources of data concerning cooling, many of which have major flaws if used to try to describe accidental environmental cooling. Animal models, and studies on anaesthetised humans during cooling for neurosurgery or cardiac surgery, are affected by the altered physiology present. Most anaesthetic drugs affect some or all of the vascular, autonomic nervous system and central responses to cold as well as abolishing voluntary effort. Normal volunteer studies rarely cool the subjects below 35°C and thus study cold stress rather than significant hypothermia. Finally, the much quoted "experi-

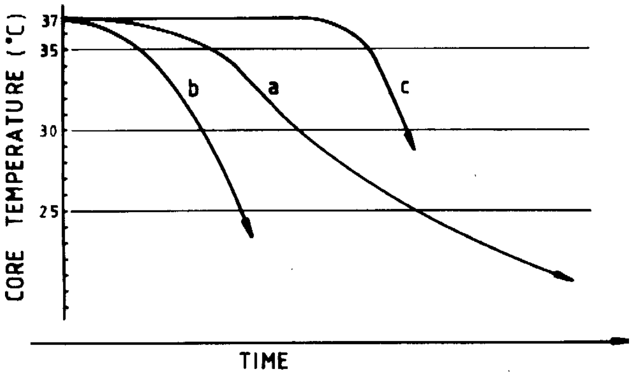

FIGURE 1.

Comparison of cooling patterns. The classical progressive cooling curve (a). Rapid cooling, e.g. a lean subject in ice water (b). The "exhaustion exposure" pattern where the temperature is initially maintained by exertion but rapid cooling ensues once the victim is exhausted and stops (c).

ments" carried out in the Second World War Nazi concentration camps, when victims were cooled to and sometimes re-warmed from extreme levels of hypothermia were carried out on people who were usually malnourished and emaciated.

Most immersion cooling experiments have been carried out with the subject at rest in a cold water bath with the head out. This is, of course, vastly different from swimming in turbulent water with a wet head exposed to spray and a cold wind. In a fully vasoconstricted adult, 40% or more of total body heat loss can occur through the scalp, face and neck. Exercise alters blood flow distribution, altering heat loss dynamics and increasing the rate of heat loss. In the case of exercise to exhaustion, in or out of water, increased heat loss may initially be balanced by increased heat production. When exercise slows or ceases, rapid net heat loss results as the glycogen depleted, exhausted body may not be capable of high involuntary heat production, and in some cases may not ever shiver. Death may follow rapidlyu and occur at a relatively higher temperature than expected from the cassical cooling curve. This situation is probably best illustrated by the mountain exposure cases who have struggled on to within sight of a refuge only to die shortly after stopping to rest.

In other cases, especially the rapidly cooled very fit subject, core temperatures as low as 24°C have been observed with the victim still conscious and shivering violently.

As survival chance seems more closely related to clinical status than actual core temperature, the Swiss Alpine Rescue approach for first aid situations has merit. Hypothermia is graded by signs and symptoms rather than by measured temperature, with higher conscious state and presence of shivering being favourable signs. This is not, however, to deny the usefulness of temperature measurement as a management aid for rescue or medical teams. For this purpose either an electronic temperature probe or at least a sub-normal thermometer is required, as normal clinical thermometers do not read below 35°C.

Predicted survival/time graphs are also very variable and unreliable because of the widely varying net cooling rates that result from body build, fitness, behaviour and all the other factors mentioned. Some individuals can be incapable of maintaining core temperature in tropical waters of 26°C or even 28°C whilst some cold resistant long distance swimmers and shipwreck survivors have coped with waters of 10°C for a prolonged period.

Being obese and passive seems beneficial, and whilst alcohol is certainly a risk factor for falling into the water in the first place, there is some evidence that inebriation may also be protective and a factor in survival in some circumstances.

Passive Rewarming

A fallacy often perpetuated about cooling is that "below a certain temperature, the victim is incapable of self-warming, and external heat must be provided". Whilst any animal is alive, heat is being generated by metabolic reactions. Human basal metabolic rate drops to half normal only at a core temperature of 28°C. The correct interpretation of observations made on rescued hypothermia victims should be that it may be extremely difficult to stop all heat loss, however, provided insulation is adequate (including reduction of evaporative skin and respiratory tract loss) anybody who is alive will slowly spontaneously rewarm. The thickness of "doona" or sleeping bag that is normally required for comfort in the cold should emphasize that the insulation necessary for field rewarming is considerable. More than one hiker's foam mat is probably necessary for insulation from the cold ground or boat deck underneath, with thick, windproof insulation around the victim.

If available insulation is inadequate, other bodies huddled together form a good substitute. The bare skin to skin contact commonly recommended however is often impractical and may not be as safe as huddling fully clothed or in separate sleeping bags. As previously mentioned, while skin warmth may feel good, any resultant reduction in shivering may in fact reduce net heat gain despite temporary improvement in comfort. Ideally, several companions should join the "huddle" as one additional person only provides a poor percentage of insulation cover for the victim.

As previously mentioned, insulation of the head and neck is most important, and any wetness of skin, clothing or blanket will cause considerable evaporative heat loss. If it is impractical to gently strip and dry off the victim without further exposure to cold or rough handling, the best way to prevent evaporative loss is by completely enclosing the clothed victim in a plastic bag from the neck down. This also serves to keep the wet survivor from soaking dry insulation placed over this bag. If exposed to the weather, or a second plastic bag or sheet over the dry insulation will keep rain and wind off, thus “keeping the dry stuff dry” and maximising insulation, even if the victim remains wet and uncomfortable.

As vapour tight is the ideal for the inner layer, a bag is preferable to plastic sheeting, however even a set of waterproof clothing will be beneficial. The large garbage bags used for 240 litre wheeled bins are cheap and readily available, although a bit short for adults at about 150 cm long. Full size bags are available from many bushwalking suppliers. Aluminised plastic “space” blankets are probably over-rated. Although radiant heat loss may be significant in a warm skinned newborn infant, the skin of a hypothermic victim is usually close to environmental temperature, and net radiant heat loss is thus not a major factor. Although not usually in bag form, “space blankets” are nevertheless very compact large plastic sheets. The type of plastic used however presents problems in many rescue environments. Being an ultra high density film, it is very strong for its thickness when only blunt forces are applied. Any puncture or tear, however, rapidly propagates and, especially in the wind, these “splitting” sheets can be rapidly shredded to ribbons. As a final disappointment, Royal Air Force tests failed to show improved radar response if liferafts were draped with the reflective film.

Airway “Warming”

The other source of heat loss is from the respiratory tract, with a larger proportion of the heat being lost by evaporation than from breathing cool air in and warm air out. In cold dry air, 25 or 30 watts (approximately 100 kJoules/hour) will be lost this way (or more if exercising or shivering violently). Any reduction in this is useful. Merely wrapping clothing around the head will help somewhat,whilst the moisture exchange humidifiers sometimes used in anaesthesia (e.g. “Thermovents”) are quite effective. Best of all is heated, humidified air or oxygen, which can provide 100% “airway heat loss prevention”. There is little additional benefit from fully humidified gas heated much higher than 40°C, as evaporation is the main heat loss source prevented, and indeed attempts at further “core rewarming” by using higher temperatures may risk airway burns and cardiac instability. In many instances, use of airway heat and humidity will not increase the usual spontaneous rewarming rate of 0.5°C - 1.0°C per hour, but it tends to reduce shivering and thus metabolic requirements and cardiac workload without reducing core temperature rise. Being non invasive and without significant side effects, it is an excellent technique to use.

Warming

Minimisation of all further heat loss, thus allowing slow, passive warming of hypothermic survivors as described is the safest method of rewarming for all first aid situations and probably also for all but experienced, intensive care equipped medical facilities. Medical practitioners often feel uncomfortable with this as there is an interventionist urge to “do something” to correct the “abnormal test results”, in this case core temperature reading. Hypothermia alone however, although a potentially dangerous condition, is in many ways protective rather than damaging, as is demonstrated by the deliberate cooling to as low as 10°C, of some patients requiring induced cardiac arrest for surgery with subsequent full recovery. In the case of elderly, slowly cooled urban hypothermia victims, rapid uncontrolled rewarming is definitely dangerous. Even 0.5°C per hour may be too fast to allow metabolic derangements to correct themselves. Young, healthy, rapidly cooled victims however tend to do well whatever methods are used, leading to case reports of success using many different methods. An examination of the likely causes of post rescue death, which is not uncommon, however, demonstrates some of the potential pitfalls.

Post-Rescue Death

Most severely hypothermic victims will be dehydrated, with slowed respiration and pulse and a low blood pressure. This reduced circulation is adequate for survival given reduced metabolic demands and a vascular system that is either lying horizontally or supported by immersion in water, thus allowing continued cardiac and cerebral perfusion at low pressures. The hypothermic heart has a lowered threshold for fibrillation and may fibrillate spontaneously if venous return drops, or if there are other stimuli for the heart rate to increase.

Conscious survivors who die during winching up to a helicopter by an underarm strap (as has occurred in Bass Strait, the Fastnet race disaster and other cases) probably suffer loss of hydrostatic support, resulting in their reduced blood volume pooling in the legs. This causes sudden reduction in venous return to the heart, which, combined with anxiety chest squeeze and skin chilling from evaporation in the helicopter rotor wash, all combine to induce ventricular fibrillation in the sensitized heart. As it is often impossible to defibrillate a cardiac arrest victim with a core temperature below 30°C, death has resulted in many of these cases.

It follows that any victim suspected of being hypothermic should be kept horizontal, or legs up during rescue and rewarming. This requires a stretcher, or if this is impractical, a double strop (one under the knees, one under the arms) for helicopter, crane or winch recovery.

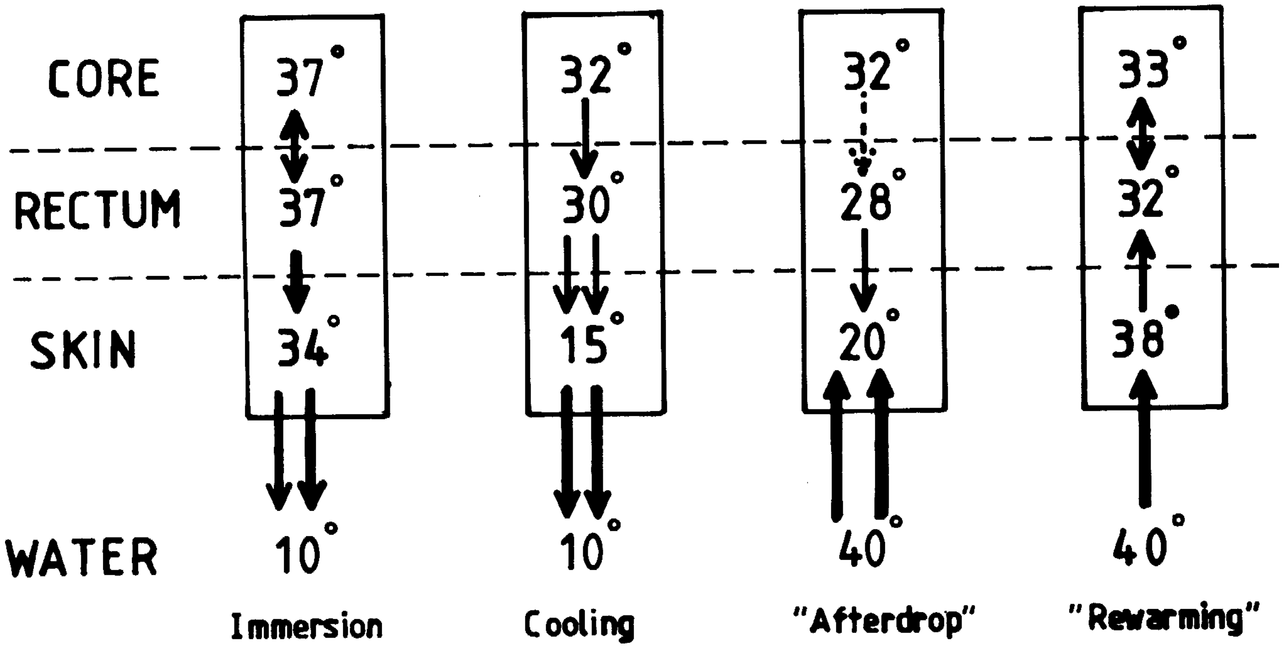

FIGURE 2.
Illustrative model of immersion hypothermia and rewarming demonstrating rectal temperature "afterdrop" without significant central core "afterdrop". Arrows show net heat flux.

Early rewarming death probably results from a related mechanism. As warming proceeds, surface and peripheral blood vessels dilate, reducing blood flow resistance and requiring increased cardiac output to maintain blood pressure, especially given a low blood volume. The cold heart again may not be capable of the necessary increased rate and may fibrillate. This is most likely to occur during rapid external warming, such as can result from using radiators, fire, hot water bottles or blankets or hot water immersion. Appropriate intravenous fluid infusion (which should be warmed if possible) combined with appropriate warming should prevent such deaths, and close monitoring of pulse, blood pressure and central venous pressure is recommended.

"Afterdrop"

Especially when "core" temperature is measured rectally, it is common for the measured temperature to continue to fall for the first 10 to 20 minutes after warming commences. As this time coincides with the pulse rise and blood pressure drop mentioned above, and the associated risk of early rewarming death, this temperature "afterdrop" has been blamed for rewarming complications. It has been assumed that as circulation increases, cold, acidotic blood starts to flow from the legs and arms, resulting in central blood temperature drop and cardiac instability. This is the reasoning behind leaving the arms and legs out during water bath rewarming. "Afterdrop" however is largely a rectal temperature phenomenon. When cardiac temperature is measured with a Swann-Ganz probe or an oesophageal probe, afterdrop is either much less than measured rectally or absent, and Golden has shown that "afterdrop" can be measured at a site 10-15 cm in from the surface in both water filled copper cylinders and pig cadavers which are cooled and then rewarmed. This phenomenon can be explained by passive thermodynamics and sensor location, and it seems likely that human afterdrop is similar.

See figure 2.

Severely vasoconstricted limbs contain little blood anyway, so where rapid immersion rewarming is appropriate then the limbs might as well be immersed so that they are both hydrostatically supported, and acting as additional "heat exchangers" to aid the rewarming.

Another proposed theory for cardiac irritability suggests that if the blood entering the heart is colder than the heart, the cardiac conducting system is selectively cooled and electrical impulses are more likely to travel via the muscle tissue, predisposing to arrhythmias and fibrillation. Significant temperature gradients are more likely to occur with rapid cooling and are presumably less likely if rewarming is slow and even, or "central" in nature (e.g. spontaneous, airway heating, peritoneal lavage or cardiac bypass techniques).

The other major groups of post rescue complications and deaths occur much later, and most frequently affect the elderly or the victim with concurrent disease that in some cases may have contributed to the exposure situation. These may include drug overdose, diabetes, malnutrition, trauma, or infection. Especially when the hypothermia has been of slow onset or long duration, excess fluid becomes trapped in body tissues ("cold oedema") and thus on rewarming the blood volume that was initially reduced by dehydration may become fluid overloaded, resulting cardiac, pulmonary or cerebral complications. Post rewarming infection is also a major problem that frequently requires treatment.

Rewarming Recommendations

The optimum method of rewarming remains a subject of much debate. Appropriate decisions however become much easier if specific situations are considered rather than just the label "hypothermia". Experienced intensive care units capable of a high level of monitoring and physiological control have reported good results with many different methods and rates of rewarming.

Fairly rapidly cooled (e.g. by cold water immersion) victims, especially if young and otherwise healthy, and especially if still conscious and shivering when found, tend to tolerate rapid hot water bath (35-38°C) rewarming well. Certainly if an immersion victim is only cold stressed (T_{core}>35°C) or perhaps mildly hypothermic but fully conscious, the comfort and speed of warm water rewarming will be much appreciated.

In other cases, or in the field however, the aim is prevention of all heat loss, thus allowing "passive" rewarming as the method of choice. This method can be continued once medical care is obtained, with the addition of continuous blood pressure, pulse, CVP and temperature monitoring, IV fluids and biochemical monitoring. (The current consensus of opinion is that blood gas results should not be adjusted for temperature before interpretation and intervention).

If the patient is rewarming and complications arise, it may be necessary to reduce insulation and slow the rewarming, especially in the chronic hypothermia case. In some cases, 0.5°C or even 0.25°C per hour may be the maximum tolerable. It will thus take many hours before normothermia is attained.

If the victim fails to rewarm, additional insulation and/or active heating must be used. The main indication for active, rapid warming are when hypothermia complicates management of other illness (e.g. trauma requiring surgery, diabetic or other medical emergency) or when there has been submersion, and near drowning or when the victim presents in cardiac arrest or arrests during treatment.

If active, rapid warming is required, an increasing number of successful case reports support partial (femoro-femoral) cardiac by-pass as the method of choice. This method provides assistance to the circulation, control of fluid balance, electrolytes and if necessary oxygenation as well as very high possible warming rates if the necessary equipment and skills are available (open heart surgery units). In other centres peritoneal dialysis is a useful addition to heated humid oxygen, insulation and heating mattresses, and also helps control electrolyte and fluid imbalance.

Other techniques reported have major drawbacks. Neither gastric nor rectal nor bladder irrigation exchange heat as well as peritoneal lavage and rather than help control fluid and electrolyte problems, gastric lavage in particular can cause water intoxication. Mediastinal lavage requires thoracotomy, which allows direct cardiac massage, but carries a high complication rate by comparison with other techniques. Short wave diathermy is very difficult to control and thus risks hypothermic tissue "cooking", and hot external packs must be likewise very carefully controlled to prevent excessive heat or pressure resulting in tissue necrosis. Water bottles, etc. at temperatures of 45°C or more have caused extensive tissue loss in some cases due to the very sensitive nature of cold skin, and other tissues, and their low blood flow. Finally the waterbath can be effective, but makes "tube management" and monitoring difficult, and in the cardiac arrest case, cardiopulmonary resuscitation (CPR) becomes athletic, difficult and somewhat chaotic and defibrillation is impossible in the bath and highly dangerous in the water soaked immediate environs.

Severe Hypothermia

Cases where a hypothermia victim is apparently dead when discovered are of significant concern, as inappropriate decisions and care can result in the death of an often young, healthy person who might have fully recovered. The following have been documented as not necessarily incompatible with survival in the severely hypothermic: apparently absent pulse and respiration, fixed dilated pupils, "rigor mortis" like rigidity and absence of response to pain, etc., minor skin decomposition, dependant lividity, glazed eye surface, sea foam in mouth or prolonged submersion. At the Mountain Medicine Symposium organised by the Institute of Ambulance Officers (TasmaniA) in 1987 Captain M.J.Nemiroff, a doctor in the U.S.Coastguard, presented a personal series of over fifty cases of survival often prolonged submersion in cold water. He now recommends resuscitation and rewarming of any victim of up to 60 minutes of submersion in water of 20°C or lower. Forty five of his fifty cases had suffered no significant clinical neurological impairment despite documented submersions ranging from six to sixty minutes and although most victims were very young, this was not always the case. Cases like these, and cases of prolonged survival after up to four hours of CPR and documented cardiac arrest after avalanche burial reinforce the tolerance to hypoxia that hypothermia may confer in some cases.

Hypothermia and CPR

The question of whether CPR should be performed in the apparently lifeless, cold individual is often asked. There is little doubt that CPR is counterproductive and dangerous if the victim has a spontaneous heartbeat. If a cold victim is discovered with no obvious, gross trauma or putrefaction, a good period of time should be spent looking for signs of life. Any breathing can be presumed to indicate heartbeat, even if nil is apparent. A full two minutes should be spent looking and feeling as rates may be very slow. Any movement is a sign of life, and the eyelash and corneal reflexes are reported not to be lost until the core temperature drops below 24°C or 25°C. The Antarctic Division recommends using an opthalmoscope or torch held close to one's line of sight to look for a "red-reflex" through the victim's pupils. Bright red at the back of the eye presumably indicates red, oxygenated blood and therefore life. Finally, if available, an electrocardiograph (ECG) can also be used to look for an organised cardiac rhythm, or a doppler stethoscope to listen for blood flow.

If life is present, field treatment should include very gentle handling and maximal insulation with either transport to a medical facility or waiting for arrival of on-site care whichever is most appropriate to the situation.

If there has been witnessed submersion with cardiac arrest when rescued, or if a rescued survivor suffers collapse and cardiac arrest during rescue or rewarming, there is little controversy about the recommendation to perform CPR.

Normal rates are recommended, as there is little sense in making a low efficiency techniques less efficient by using reduced rates of compression and ventilation. Recovery after prolonged CPR is perhaps explained not only by metabolic tolerance created by hypothermia, but also by rigidity of the cold heart making it a more efficient conduit for a circulation created by compressing the lung vasculature (now believed to be a major mechanism of CPR action). The cardiac arrest victim should be aggressively rewarmed, as defibrillation is often not successful until the core temperature exceeds 30°C, and resuscitation should not cease until the temperature exceeds 32°C. Although an initial defibrillation attempt may be made, repeated defibrillation or drug therapy is probably not indicated below T_{core} 30°C. Drug doses which have not been effective due to peripheral pooling may be mobilised and become active and toxic as the victim is rewarmed. Many drugs have reduced effects when the subject is cold, and most anti-arrhythmics are ineffective. It is suggested that Bretylium however may retain its action, and that it should be tried early in these cases. Spontaneous cardioversion may occur and seem more common with "core rewarming" techniques.

Victims who are apparently dead upon discovery, but who might perhaps have a chance of resucitation, form the remaining group, and here a certain degree of pragmatism is appropriate. It is important not to risk the lives of rescuers or definite survivors. If feasible and safe, CPR can be commenced if it is believed that it can be continued until the victim is rewarmed, and that good medical facilities can be reached within, say, four hours. If there is any doubt, however, the victim's best chance probably lies in the existence of undetectable life rather than resuscitatable death of unknown duration and maximal insulation and observation at least gives some chance rather than immediate, on site declaration of death. Although death is classically said to occur from cardiac arrest (usually ventricular fibrillation) as the core temperature drops below 25°C, survivals have occurred following core temperatures as low as 15°C in exposure victims, and in controlled operating theatre induced hypothermia, humans have been cooled to below 10°C and subsequently rewarmed.

On a number of occasions, urban hypothermia victims have been erroneously delivered to the morgue, only to exhibit signs of life the following morning after a night under a cover in the comparative warmth of a non-refrigerated morgue holding room. These and other remarkable survivals from differing situations where hypothermia has been a factor reinforces the dictum that no case should be considered hopeless until the victim is "warm and dead".

Further reading

For those further interested, the following two recent and well referenced works are recommended:

The Nature and Treatment of Hypothermia
Eds. Pozos and Wittmers
University of Minnesota Press, 1983

Hypothermia and Cold Stress
E L Lloyd
Croom Helm, 1986

This paper has been adapted from a lecture given at the joint SPUMS and Royal Hobart Hospital meeting in Hobart in November 1988

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