Accidental Hypothermia In Man

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SUMMARY

Much is yet unknown on the pathogenesis of accidental hypothermia in man. Data are mainly derived from comparative physiological studies in mammals, but some knowledge has been obtained from direct clinical observation and the experience gained with induced hypothermia in anesthesia. The usual criteria of death do not apply to hypothermia and awareness of the altered physiology under such conditions is essential for quick and effective treatment. There appears to be a shift in rewarming procedures from superficial rewarming by conservative methods to the more aggressive forms of central rewarming. Despite practical limitations the latter methods, especially peritoneal dialysis, are more effective and decrease mortality.

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A TEMPERATURE below 35°C (95°F) can theoretically be accepted as criterion for hypothermia.[5] Individual variation should however be taken in consideration. Age is another important parameter. Women have a higher basal temperature than men, and in addition a monthly resetting of the thermostat, characteristic of fertility. Geographic and ethnic factors have their bearing on body temperature, and recently the attention has focused on circadian changes.

An impressive amount of data on environmental factors has been obtained from comparative thermal physiology of different homeotherm and poikilotherm mammalians. Insight into the effects of hypothermia on men has been gained more haphazardly, originally mainly through observation of patients accidentally exposed. Observations under these circumstances are usually interrupted by simultaneous efforts towards reviving the patient. Only once were the ultimate effects of hypothermia studied through human experimentation.[1] Subjects were put up to their heads in a waterbath of 4°C. Most died after 65 minutes; only one survived for almost three hours. Final rectal temperatures varied from 24°C to 29°C. When the temperature fell to about 30°C, auricular fibrillation invariably occurred. The pulse rate progressively slowed to 40 per minute shortly before death, and was followed by fatal ventricular fibrillation.

Induced Hypothermia

The therapeutic effects of hypothermia became known in the late forties. Already during Napoleon's campaign in Russia, frozen extremities were amputated painlessly. Later, a British physician, Dr. Fay, used hypothermia to combat fever, by cooling chest and extremities to 32°C for four days. In 1950, during the French war in Indo-China, an army surgeon discovered that he could keep serious casualties alive longer when he cooled them. This method, termed 'artificial hibernation' was perfected by Dr. H. Laborit in Paris, France. With a combination of drugs including chlorpromazine and pethidine, the so called 'lytic cocktail', he counteracted the temperature raising effects of shivering, and with subsequent whole body cooling, induced hypothermia. This method was used during Dr. C. N. Barnard's first heart transplantation six years ago. The heart of the donor was cooled to 10°C and transplanted into the recipient, whose rectal temperature was maintained at 26°C. Open heart surgery has remained the major indication for induced hypothermia.[3]

Problems of Whole Body Cooling

Several bothersome problems are encountered during whole body cooling, e.g. a high incidence of ventricular fibrillation and anuria during the first 24 hours postoperatively.[9] For this reason it never became popular for the treatment of asphyxia in newborns, where it had been used successfully by Finnish physicians.[25] Selective, rather than whole body cooling, is used in the treatment of brain injuries for prevention of cerebral edema and convulsions.[29] Negrin introduced spinal cord cooling for treatment of cerebral palsy and multiple sclerosis, while Wangensteen treated gastric ulcers by freezing down to −16°C. Extreme cold destroys tissues with knife-like precision. It causes little bleeding and usually anesthetizes as it works. The dermatologist removes warts this way. In gynecology cryosurgery is employed increasingly for the management

of benign lesions of the lower genital tract and is sometimes used for condylomas of the vulva, endometrial hyperplasia, chronic erosions of the cervix and ectropions.[4] Ophthalmologists use cryostylets to remove cataracts and reattach retinas, while oncologists are applying it to the treatment of primary and metastatic bone tumors.[15] Freeze drying or cooling by liquid nitrogen to −175°C, at a rate of 1°C per minute, is used for storage of specific tissue cells. By adding glycerol or dimethylsulfoxide (DMSO), heart valves, cornea transplants, blood, semen and pathological specimens can be stored in containers for long periods of time.

Accidental Hypothermia

Accidental exposure to cold may occur with immersion,[16, 20] in campers or mountain climbers,[11, 19] in miners,[22] in patients with myxedema, overwhelming infection or involvement of the posterior hypothalamus[18, 26] or following alcohol or barbiturate intoxication.[13]

The world's lowest rectal temperature in a surviving patient has been recorded in a 23 year old black, inebriated female who was exposed for 11 hours to an environmental temperature of −24°C and a relative humidity of 65 percent.[10] Heart rate on admission was between 12 and 20 per minute, irregular, with episodes of asystole. Respiratory rate was between three and five per minute. Blood pH was 7.17 as a result of stasis and lactic acid accumulation as well as CO^2 retention. A bloodsugar of 418 mg percent was interpreted as a stress response of the adrenal medulla. It took 20 hours to bring her rectal temperature of 18°C back to normal. Due to frostbite, amputations had to be performed on all four extremities, but otherwise the patient survived without sequelae, probably in part due to her good nutritional state. She did experience retrograde amnesia, a known occurrence under these circumstances.[24]

Comparative Rates of Heat Loss

Heat loss by convection and radiation (exposure to cold air) is slower than by conduction (immersion in cold water or laying on the ground). Also, water has a greater heat storage capacity than air.[28] As a result, the rate of temperature drop with immersion is higher. However, no good correlation has been established yet between this rate and the chance of survival. In seawater of −1°C, survival is less than one hour.[16] At 15.6°C, this time limit can increase to six hours. Above 15.6°C maximum survival time is greatly prolonged, since heat balance can be maintained. Swimming accompanied by shivering may raise heat production to six times resting values.[2] Individual factors, such as subcutaneous fat layer, peripheral vasoreactivity and acclimatization to cold also play an important role. Acclimatization or adaptation to cold[7, 23] is characterized by a reduced heat loss rather than an increased heat production. Studies among well trained divers in polar waters[14] and among Korean diving women[8] have shown a reduced critical water temperature, resulting in shivering at lower core temperatures, as a mechanism of heat preservation.

Criteria of Death in Hypothermia

Patients have been declared dead as a result of hypothermia, and yet have subsequently revived, illustrating the point that the usual definition of death is not applicable under these circumstances. 'Failure to revive on rewarming' appears to be a practical definition of death from accidental hypothermia.[30] With a body temperature of 30°C, blood supply can be stopped completely for ten minutes without permanent brain damage. At body temperatures of 20°C, this time can be extended to 25 minutes. Therefore one cannot declare a hypothermic patient dead through cardiac arrest alone. Barbiturates may lower the oxygen consumption of the brain and prolong survival. It becomes very difficult to feel a patient's pulse at body temperatures below 30°C. Below 20°C, registration of an EEG becomes impossible, even though the blood circulation to the brain is still functioning. At a body temperature of 25°C, tendon and pupil reflexes cannot be elicited. Dilated pupils in such patients are no evidence of death. Awareness of these factors will influence diagnosis.[12]

Treatment of Accidental Hypothermia

Results of treatment depend on duration and character of exposure, degree of core cooling, physical condition prior to hypothermia, including nutritional status and quality of clothing, and not in the least on treatment facilities available. From experience with induced hypothermia, it has been learned that after short duration cooling to 27°C, or more prolonged cooling to 30°C, the body can rewarm spontaneously providing there is good insulation. However, peripheral vasodilation can cause shunting of blood away from the warmer body core to the colder peripheral tissues. This may result in a severe 'after drop' in core temperature and a simultaneous fall in blood pressure, which in some cases will be fatal. For that reason alcohol, a potent peripheral vasodilator, is absolutely contraindicated during rewarming procedures. Warm glucose drinks are permissible since in addition to providing central heat, they restore the depleted glycogen reserves. When the body temperature is below 30°C, the patient can be put in a warm water tub with the extremities outside to prevent peripheral shunting. Initially the water temperature should be around 34°C. Over the next ten minutes the temperature of the water can be raised, but not higher than 42°C, to avoid skin damage. In the absence of warm water, electric blankets or infrared light can be used.

Once the rectal temperature has risen to 34°C, active rewarming is stopped, and the patient is allowed to recover spontaneously. Accompanying problems like cardiac arrhythmias, impaired respiration and lactic acidosis are treated accordingly. Hypotension is treated by plasma expanders, but care should be taken not to overload the circulation, since a cooled heart may be unable to cope with this.

Faster Rewarming Methods

Recently attention has been drawn to faster and more effective ways of rewarming which have also supposedly reduced mortality.[6] They include rewarming of the heart after thoracotomy,[13] rewarming by extra corporeal circulation[27] and similar sophisticated procedures requiring specialized hospital staff and equipment. Because the issue of core versus surface rewarming is an important one, an experimental study was done in dogs, with peritoneal dialysis as the method for core rewarming.[17] It was clearly demonstrated that this method was faster than superficial rewarming and carried far less risk of dangerous complications. Virtually no shunting of heat to the periphery occurred and the cardiac danger zone of 28°C was quietly passed without triggering arrhythmias. However, when extrapolating the results from dog to a standard 70 kg man, at least 60 liters of warm dialysate would be required to

rewarm him during 90 minutes from a core temperature of 25°C. This may not be practical under all circumstances. Besides, the risk of peritonitis increases linearly with the duration of dialysis. Despite these practical limitations the method is effective and decreases mortality. ◀

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QUOTE

Among the therapeutic agents not to be found bottled up and labelled on our shelves, is Travelling; a means of prevention, of cure, and of restoration, which has been famous in all ages.

Daniel Drake (1789-1875) in Western Medical and Physical Journal 1:305, 1827