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REWARMING FROM ACCIDENTAL HYPOTHERMIA BY VENTILATION WITH WARM --ETC(U)
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Rewarming from Accidental Hypothermia by Ventilation with warm gases

by James J. Jaeger

Accidental hypothermia continues to be a problem encountered by mountain rescue teams, ski patrols, and emergency medical treatment facilities despite the increased public awareness of the dangers of prolonged exposure to chilling environments. Effective treatment of hypothermia has been limited to two types of procedures; external and internal rewarming. Recent investigations have shown that two forms of internal rewarming, peritoneal dialysis and arteriovenous shunting through an extracorporeal heat exchanger, are superior to external techniques by virtue of a more rapid rise in body temperature and a decrease in the incidence of complications such as an afterdrop in core temperature, "rewarming shock", arrhythmias, and ventricular fibrillation. Since both periotoneal dialysis and A-V shunting are surgical procedures, attention has been drawn to a technique of rewarming by ventilation with warm gases (air or O_2). This procedure is non-invasive and a system could be developed so that it could be used by paramedics in the field. Inhalation rewarming was first introduced by Lloyd in 1972 (4), and has since been examined in detail by a number of investigators (1,2,3).

Inhalation rewarming is an attractive concept since it utilizes a highly efficient heat exchanger through which nearly the entire cardiac output passes. In addition, the warmed blood passes directly to the heart thus minimizing heat loss to peripheral tissues. Actual cases where inhalation rewarming has been used to rewarm hypothermic humans have demonstrated that: (1) rewarming can be accomplished; (2) the afterdrop in core temperature following initiation of rewarming can be eliminated or at least minimized; (3) there is immediate and continued improvement in pulse rate and blood pressure (2,3).

The major drawback of using inhalation rewarming to treat hypothermia is that the time required for complete rewarming is approximately the same as that achieved by using external methods alone (2,3,4). The reason for this is the relatively low heat capacity of air or oxygen. The amount of heat transferred by this technique is increased considerably if the inspired air is humidified. This is due to the latent heat transferred to the respiratory tract surfaces when water vapor condenses. In fact, if a careful analysis of the inspired and expired air temperatures and water vapor contents were available on the case histories of inhalation rewarming, it would probably show that most of the heat transferred was due to condensation of water vapor and that only 10 to 20% of the total heat transferred was due to convective heat transfer by the gas. Nevertheless, the rate of heat exchanged by ventilation with warm humidified gas is still only a small fraction of what can be achieved by other internal rewarming techniques.

The fact that the inspired gas is usually humidified at a temperature greater than the body temperature of the hypothermia victim brings up a point which has not received due consideration in the literature on inhalation rewarming. The condensation of water vapor in the respiratory tract can lead to significant accumulation of water in the lungs. Whether or not this will represent a serious complication during rewarming depends on the following factors: the temperature and water vapor gradients employed; the length of the rewarming procedure; the position of the victim; and the ability of lung tissue to keep the pulmonary exchange surfaces "dry". While the first three factors can be controlled, the fourth factor can not be assessed. The magnitude of the respiratory water load that can be tolerated during hypothermia awaits future physiological investigations. In the meantime, inhalation warming devices should include circuitry to limit the water content of inspired air to a value which does not exceed the value for saturated air at the body temperature of the hypothermia victim. This conservative approach will certainly reduce the rate of heat exchange, but it will eliminate the risk of excessive water in the lung.

In deciding on which method of internal or central rewarming to employ, benefits must be weighed against risks. In a rescue situation or in a remote location, the simplicity and portability of the inhalation rewarming technique recommends it for use. However, proper attention must be given to the risk of excessive water vapor condensation in the respiratory tract. Once the victim has reached a well equipped medical facility, a decision must be made whether to continue the slow rewarming rate by ventilation with warm gas, or to switch to the faster rewarming available with peritoneal dialysis or an arteriovenous shunt. The potential benefits of rapid rewarming must be weighed against the increased patient risk.

Further discussion of this problem is encouraged and should be directed to CPT James Jaeger, US Army Research Institute of Environmental Medicine, Natick, Massachusetts 01760.

The opinions and assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army of the Department of Defense.

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