21 Prediction of severe body cooling in a hypobaric environment

Y. Nishi, Hokkaido Institute of Technology, Sapporo, Japan

Major changes in the heat transfer processes on the human body under hypobaric environments occur in heat transfer coefficients for convection (h'c) and for evaporation of sweating (h'e). A ratio (h'e/h'c) is known as the Lewis relation and is defined in terms of barometric pressure (Pb), in Torr, by LR=(h'e/h'c) = 2.2(760/Pb). In the equation above a term (h'c) is ais6 affected by (Pb) and is given by $h'c=hc\,(Pb/760)^{0.55}$, where (hc) represents a sea level value. These relationships indicate that at 0.4 ATM the rate of convective heat loss decreases as much as 40%, contrary to the evaporative cooling power of the environment which increases up to 50%. The following equation describes the rate of respiratory dry and evaporative heat losses, (C + E) res, at a barometric pressure Pb in terms of the rate of pulmonary ventilation and enthalpy difference between exhaled and inhaled air.

$$(C + E)\,res = Vbtps*(Pb-Pa)/760*10^3/28.34/T*(iex-iin)$$

where:

Vbtps= pulmonary ventilation. body temperature and pressure, saturated with water vapor in l/hour
Pa= ambient vapor pressure in Torr
T= absolute temperature in K
iex,iin= enthalpy of exhaled and inhaled air in kcal/kg.DA

As is well known the volume of pulmonary ventilation increases inverse-proportionally to the barometric pressure. And furthermore enthalpy of expired air increases significantly under hypobaric conditions, since the water vapor content is not affected by ambient pressure in the thin air. Thus assuming the exhaled air is saturated with the water vapor, the product of the increased Vbtps and enthalpy difference (iex-iin) is several times as much at high altitude mmpared with sea level conditions. For example at 0.4 ATM or at an altitude of about 7000 meters with ambient air temperature of minus 30 degrees C, man may lose 80 to 100 kcai of body heat in one hour, since his pulmonary ventilation rate is expected to increase as much as five times, and this heat loss corresponds to the resting metabolic energy.In other words man may lose all of his metabolic heat through respiration. It seems that quite a few numbers of fatal accidents at high altitudes might be caused by the failure of physiological adaptation related with the hypoxia. However, severe body cooling resulting from hyperventilation may also easily extend the climber to the limit of his physiological tolerance.